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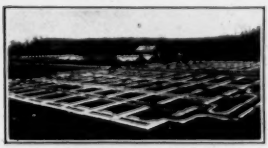

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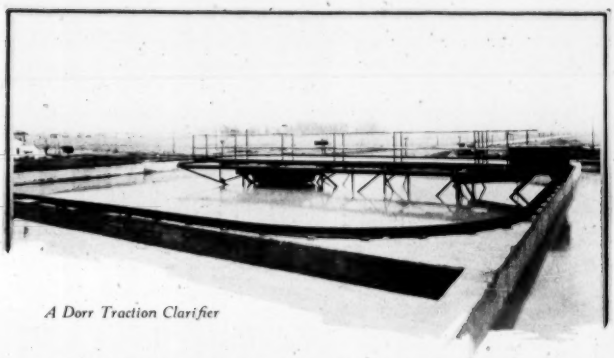

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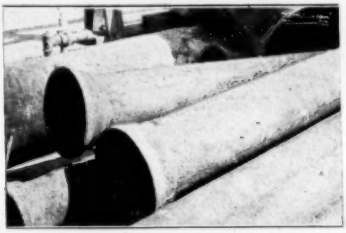

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Page

Federation Affairs:

Organization and Purpose of the Federation of Sewage Works Associations. By Chas. A. Emerson, Jr. ... 3

Aims of the Central States Sewage Works Association. By Adolph Kanneberg and L. F. Warrick ... 5

Federation of Sewage Works Associations Constitution and By-Laws ... 9

Sewage Research:

The Effect of Age of Sewage Solids upon Their Digestibility. By Gordon M. Fair and Louis Klein ... 14

Composition and Decomposition of Fresh Sewage Solids Collected from Different Parts of a Settling Tank. By H. Heukelekian ... 19

Comments on Methods for Determination of Residual Chlorine. By Linn H. Enslow ... 30

Experiments on the Purification of Beet Sugar Wastes by Stream-Flow Aeration. By Max Levine and G. H. Nelson ... 40

Sewage Works Operation:

Carbohydrate Wastes Stimulate Growth of Undesirable Filamentous Organisms in Activated Sludge. By E. H. Morgan and A. J. Beck ... 46

Bacteriological Isolation and Study of the Filamentous Organism in the Activated Sludge of the Des Plaines River Sewage Treatment Works. By C. C. Ruchhoft and J. H. Watkins ... 52

The Control of Foaming and Odors of Imhoff Tanks. Texas and California Experiences with Chlorine and Lime.

I—Tests at Lufkin, Texas. By Chester Cohen ... 58

II.—Tests at Davis, Porterville and Livermore, California. By E. A. Reinke ... 61

A Flotation-Type Nozzle for Sewage Treatment. By Frederick G. Nelson ... 64

Simple Applications of Fundamental Principles of Sewage Treatment. By C. G. Gillespie ... 68

Experiences and Experiments at the Houston Activated Sludge Plants. By G. L. Fugate and W. S. Stanley ... 70

Industrial Wastes and Stream Pollution:

Improvements in the Operation of a Textile Wastes Treatment Plant. By Stuart E. Coburn ... 77

Treatment of Laundry Wastes. By L. E. Sakers and F. M. Zimmerman ... 79

Editorial:

The New Journal ... 83

Chlorine and Sewage Odors ... 84

Sludge Disposal ... 85

Proceedings of Local Associations:

Condensed Minutes of Most Recent Meeting of State and District Sewage Works Associations ... 87

Reviews and Abstracts:

A Review of American Literature on Sewage Treatment and Stream Pollution. By F. W. Mohlman ... 100

A Digest of Papers Presented at the Tenth Texas Water and Sewage Works School, Houston, Texas, Jan. 23 to 27, 1928. Abstracted by E. Hurwitz 106

Visit of German Engineers ... 109

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Federation Affairs

Organization and Purpose of the Federation of Sewage Works Associations

By Chas. A. Emerson, Jr.[1]

At the present time workers in the various branches of the sewage field, including operators of sewage and industrial waste treatment plants, scientists engaged in research, and municipal and private engineers interested in design and construction, are meeting annually in a number of our states for discussion of problems of mutual interest. These groups are known as sewage works associations, sewage and waste disposal conferences, and schools of instruction for water and sewage works operators. That the meetings are of real value to the participants is evidenced by the gradual spread of the movement; in fact, local sewage associations have been organized in two of our far western states during the past few weeks, and are being actively considered in at least four other states.

It requires but slight imagination to forecast the formation within a very few years of state and district sewage works associations throughout the land, so that each worker may have the advantage of listening to papers and taking part in discussions with a minimum amount of expense for travel.

Raising funds for publication of papers and discussions presented at these meetings has been a serious problem in all but one or two instances and resort to various expedients has been necessary.

Sometimes a state department or a state university has issued the proceedings as a bulletin, and in other cases publication has been due to the generosity of business mens' associations, or to a small group of manufacturers of sewage treatment plant supplies and equipment. Some associations have not been able to issue proceedings and no record has been made of contributions, presumably of considerable value.

At the best, these proceedings have had a limited circulation, usually reaching only the members of the particular local association, even though the papers may have been of national interest and importance.

In order for one person to receive the benefit of papers and discussions presented at all of these local associations, it would be necessary, under existing conditions, to pay dues in each and to attend meetings in various parts of the country, entailing an expenditure beyond the means of the majority.

[1] *Chairman of Federation, Fuller and McClintock, Philadelphia*

Ways and means for strengthening existing local organizations, for formation of others over a wider geographical range, and for providing a wider circulation of the papers presented at the various meetings so as to reach all interested workers at a minimum expense to the individual, have been widely discussed during the past two years. Other matters needing correction are the paucity of reliable and comparable data concerning operation of treatment plants; a lack of suitable outlets for sewage research papers, and wasted effort through presentation of practically identical papers at several different meetings.

Workers interested in the solution of these problems have met in informal discussions held in connection with conventions of the American Society of Civil Engineers, the American Water Works Association, and the American Public Health Association. A committee of one hundred members, representing every section of the country, studied for several months, and, after rendering a preliminary report, gave way to four smaller committees working under a general chairman.

Conclusions reached and recommendations made during this painstaking study were:

1. That a national sewage works association with an annual meeting would be undesirable at present, because the expense for travel to an annual convention would be generally prohibitive.

2. That desired results could best be obtained by strengthening the existing local sewage works associations and by the formation of others in each state, or in groups of two or three states taken as a unit, so that workers could attend meetings at a minimum of expense.

3. That the local associations should be joined into a country-wide Federation and be guided by representatives selected by each of the local groups to act as a central Board of Direction.

4. That a Journal should be published by the Federation containing important papers presented at all the local meetings, together with proceedings of the meetings and original research articles for distribution to every member of each local association at a moderate price.

As such a Federation was intended purely as a mutual benefit association, it was mandatory that arrangements be made to bring the costs within the means of all who might be interested. The publication of such a Journal would be a matter of great expense and could not be entirely placed upon the member associations. For the solution of this financial problem appeals were made to a group of manufacturers of sewage works equipment and to The Chemical Foundation. Through their practical interest and generosity, together with the expenditure of much time and effort by individuals throughout the country, the Federation of Sewage Works Associations has been effected and the publication of THIS JOURNAL has become possible.

The constitution of the Federation appears elsewhere in this issue. It is sufficiently broad to admit every organization interested in the "nature, collection, treatment and disposal of sewage and industrial wastes."

The continued success of the Journal and the growth of the local association can be assured through coöperation, and such coöperative action should react to the benefit of each individual, by enabling him to perform his allotted task more intelligently in the important public health field of sewage and industrial wastes treatment.

Aims of the Central States Sewage Works Association[1]

BY ADOLPH KANNEBERG[2] AND L. F. WARRICK[3]

With many organizations of various kinds in existence today, the question always asked when a new association is formed is "What need does it meet and does the need justify its foundation?" The Central States Sewage Works Association being a newly formed body, it is the purpose of this paper to review briefly the events leading to the development of the organization and to present the aims and contemplated program of activity of the group of municipal and state officials, sewage plant operators, and engineers comprising the membership.

As a result of the rapid development of our civilization making possible the collection of large masses of people in cities, new problems are created or old ones, formerly regarded as inconsequential, are magnified to such proportions or brought to our attention so forcibly that they cannot be ignored without limiting or interfering with the growth or even the existence of these cities. The proper and safe disposal of sewage constitutes one of these problems. To protect the public health and comfort municipalities are being called upon more and more to install and operate sewage treatment plants. The increasing migration of the people in the cities to the country for recreational purposes has resulted in an increasing demand for protection of our lakes and streams against objectionable pollution by sewage and industrial waste.

In the disposal of municipal wastes cities and villages should assume responsibilities for the maintenance of proper sanitary conditions within the areas of their jurisdiction. In order to secure effective results, there-

[1] *Presented at the Joint Meeting of the League of Wisconsin Municipalities and the First Annual Meeting of the Central States Sewage Works Association, Milwaukee, Wisc., May 25, 1928.*

[2] *Commissioner, Wisconsin Railroad Commission and Chairman, State Water Pollution Committee.*

[3] *Sanitary Engineer, Wisconsin State Board of Health.*

fore, they should provide the necessary sewage treatment plants and furnish at least general supervision over the operation and maintenance of all such installations.

Effective sewage treatment depends to a large extent on two primary factors: (1) adequate financial provision by municipalities, and (2) suitably trained operating personnel. The former is mainly a problem of city and village officials and should consequently be the subject of thorough study by the members of this League of Wisconsin Municipalities. The latter—the development of efficient operating personnel—is one of the chief concerns of the Central States Sewage Works Association and constitutes one of the principal motives for formation of the organization. Since it is impossible to separate these two factors completely, the closest cooperation should be obtained in the activities of the League and the Sewage Works Association.

Sewage treatment is not an empirical matter which can be successfully accomplished by any set formula or "rule of thumb" method. It is a matter which presents numerous complexities, a great many of which have not yet been satisfactorily explained. There are, however, certain underlying or basic principles which apply to all methods of sewage treatment which should be understood by a plant operator in order that he may intelligently cope with some of the common difficulties encountered in sewage plants. A lack of knowledge of these fundamentals has often resulted in the partial or complete failure of treatment works representing a considerable public investment.

Realizing the need of providing ways and means for furnishing this information to plant operators in a readily understandable and practical form, sewage works associations have been formed in various states, notably in New Jersey, Texas, Ohio and Iowa, and are successfully accomplishing this object. Each has a publication in which operating problems are reviewed and new developments are called to the attention of those who may be benefited by such information. The annual meetings of these groups tend to create or further stimulate the interest of the sewage works operators in their work through exchange of ideas and experiences which are ultimately reflected in improved operation of treatment works.

Much information of value for consulting sanitary engineers is to be found in the programs of these associations. They have become acquainted with the operating difficulties experienced with existing plants through faulty design or construction, or both, and in the design of future plants can change or eliminate those features responsible for trouble. The practicing engineer is, or should be, interested in getting the best operating results attainable with sewage treatment plants; results which are a credit to his work, and which tend to improve the standing of the sanitary engineering profession.

Because of these mutual benefits a group of interested individuals from Illinois, Indiana and Wisconsin met in Chicago, on December 17, 1927, and formed the Central States Sewage Works Association. The grouping of three states in the association was thought advisable in order to form a strong organization initially with an adequate field for building up a large membership. The constitution adopted points out that the object of this Association shall be "the advancement of the knowledge of design, construction, operation and management of sewage works and the encouragement of a friendly exchange of information and experiences." Membership is of one kind only, to be known as member, and includes any superintendent, manager or other officer of a municipal or private sewage works; a civil, hydraulic or sanitary engineer; a chemist or bacteriologist or any board, commission or department, or any person engaged in the design, construction, operation or supervision of sewage works, or in the sale and manufacture of sewage works equipment. Any person, board, commission, department, municipal or private corporation desiring membership in the Association is required to make a written request for admission to the Secretary, and election depends on a majority vote of the Membership Committee. It is thus evident that every effort is being made to include all persons, civic bodies and corporations mutually benefited by the Association.

In the program of activities special attention is being directed to the problems of the sewage plant operator of small municipalities. In this first annual meeting of the Association tomorrow's sessions are devoted entirely to this subject, with a practical demonstration of sewage plant control tests at the laboratory of the Milwaukee Sewage Disposal Works. Publication of the information in the papers and discussions presented on a national basis in the form of a Journal of the Federation of Sewage Works Associations will certainly tend toward general enlightenment on matters of sewerage and sewage treatment.

The question of obtaining funds for the operation and maintenance of sewage treatment plants offers a difficult problem in many cities and villages in Wisconsin. Of the 212 municipal sewerage systems in this state, 86 have disposal facilities through 100 treatment plants. These plants vary from ordinary septic tanks to large and complicated sewage treatment works, such as the Milwaukee activated sludge plant. The municipalities served have, for the most part, populations less than 5000, only 10 being larger on the basis of the 1920 census. Most of them in preparing their annual budgets forget sewers and sewage treatment plants, with the result that they receive little or no attention. Often, therefore, the citizens do not get value received from a considerable public investment in sewage treatment works.

Lack of action on the part of city officials is not necessarily caused by

failure to appreciate the need for sewage treatment. In most cases it is a question of financing the construction of intercepting sewers and the sewage disposal plant, and providing for the upkeep of both. The question of finance, however, can be answered. The answer is sewer rents. Ohio and Michigan and other states now have state laws which make it permissible for municipalities to establish sewer rents. Under these laws such rentals not only create a source of revenue for maintenance of sewerage systems but also can be made to cover taxable charges on sewage treatment. Another feature is that sewer bonds issued in municipalities where rentals are charged would not be subject to limited indebtedness, for they would then be placed under the same classification as water bonds.

The advantages of sewer rents may well be considered by the Central States Association and particularly, for our state, by the League of Wisconsin Municipalities. The aims of our Association are completely in harmony with those of the League and with close coöperation we shall certainly make progress in improving the status of sewage treatment and stream purification.

Editor's Note.—The Constitution and By-Laws which follow on the next page were drafted by the Organization Committee, as listed on the second page of this issue, under the Chairmanship of Mr. H. W. Streeter, of the U. S. Public Health Service. Much thought was given to the preparation of these articles. They deserve the careful consideration of the Board of Control, as well as of the individual members of the Federation. The text should be read carefully and suggestions or criticisms sent to Mr. Streeter.

It is desirable that a permanent organization be effected as soon as possible, but it is equally desirable to have as many local organizations as possible represented on the Board of Control, so that they may more fully express the concensus of opinion of the majority of local groups. The date for the first meeting of the Board of Control will be set by Chairman Emerson at his discretion.

Federation of Sewage Works Associations

REVISED DRAFT OF CONSTITUTION AND BY-LAWS

Constitution

ARTICLE I

NAME

The name of this organization shall be the Federation of Sewage Works Associations, hereinafter designated as the Federation.

ARTICLE II

OBJECTIVES

The objects of this Federation shall be:

SECTION 1. The advancement of fundamental and practical knowledge concerning the nature, collection, treatment and disposal of sewage and industrial wastes, and the design, construction, operation and management of sewage works, through the correlation and strengthening of local, state and district sewage works associations, and the publication of a journal designed to meet the needs of persons active or interested in these fields of endeavor.

SEC. 2. The promotion and encouragement of improved waterways sanitation, through the same measures.

ARTICLE III

MEMBERSHIP

The membership of the Federation shall consist of local, state and district associations or conferences, hereinafter designated as Member Associations, whose objectives and constitutions are in harmony with the purposes of this Federation, subject to the conditions and limitations prescribed in the By-Laws of the Federation.

ARTICLE IV

ORGANIZATION

SECTION 1. The affairs of the Federation shall be conducted by a Board of Control (hereinafter designated as the Board), under such rules as the Board may determine, subject to the specific conditions of this Constitution and By-Laws.

SEC. 2. The officers of the Federation shall consist of a Chairman, a Vice-Chairman, a Secretary-Treasurer and an Editor, to be selected and to serve under conditions as provided in the By-Laws.

ARTICLE V

AMENDMENTS

Amendments to this Constitution may be made by a two-thirds vote of the total membership of the Board, notice and text of all proposed amendments having been submitted to the member associations not less than sixty days prior to the meeting at which the said amendments are to be voted upon.

By-Laws

ARTICLE I

SECTION 1. Any local, state or district sewage works association or conference, or other organization whose objectives and constitution are in harmony with those of the Federation may be granted membership in the Federation by a majority vote of

the Board; provided that the constitution of the applicant association or conference has been examined and certified by the Board as being in accord with Article III of the Constitution of this Federation; and provided, further, that certification shall be made by the association seeking admission to membership that the constitution and By-Laws of the Federation are accepted by it.

SEC. 2. Any member association may withdraw from this Federation at the end of any fiscal year by giving three months notice of such intention, provided that the dues of such member association in the Federation are fully paid up to the time of withdrawal. The member association thus withdrawing shall be entitled to its proportion of any surplus in the treasury, as determined by the proportion of the number of its active members on the date of withdrawal to the total number of active members in the combined member associations of the Federation, and shall be responsible for its proportion of any deficit, as determined in a like manner.

SEC. 3. Any member association may be excluded from this Federation, at the pleasure of the Board, for non-payment of dues, as hereinafter provided, or for any change in its constitution which may bring it into conflict with the Constitution of the Federation.

ARTICLE II

DUES

SECTION 1. The dues of the member associations in the Federation shall be paid in advance at the rate of one dollar per annum for each person on the membership rolls of the respective member associations on December 31st. The fiscal year of the Federation shall begin on January 1st, and these dues shall be collectable on that date and shall have been paid before February 1st. If the dues of any member association shall not have been paid by February 1st, fifteen days notice of the dues in arrears shall be given to that association, after which time, if the dues remain unpaid, that association may be dropped from the rolls of the Federation, on action by the Board, as provided in Article 1, Section 3, of these By-Laws.

SEC. 2. In transmitting dues to the Federation, each member association shall forward with them a certified list of the names and correct mailing addresses of all individual members of the said association who are in good standing and are entitled to receive the Journal of the Federation during the ensuing year.

ARTICLE III

BOARD OF CONTROL

SECTION 1. The Board of Control, designated herein as the Board, shall consist of two representatives from each one of the member associations.

SEC. 2. The members of the Board shall be appointed in a manner to be decided by each respective member association, provided, however, that the members appointed from each member association shall be so selected that their terms of office shall overlap but no person shall be selected to serve for more than two consecutive years.

SEC. 3. The duties of the Board shall consist of general supervision over all agreements and fiscal arrangements and selection of the officers of the Federation, as hereinafter provided. The Board shall have the power to enter into agreements in behalf of the Federation and to make all arrangements, both fiscal and otherwise, for conducting the affairs and business of the Federation. A majority vote of the members of the Board present at any meeting shall be necessary for approval of all questions considered by the said Board, except amendments to the Constitution, which shall be decided by a two-thirds vote of the full Board, amendments to the By-Laws, which shall be decided

by a two-thirds vote of the members of the Board present at any regular meeting, and certain fiscal questions which shall be decided as hereinafter provided

SEC. 4. The Board shall serve one year, beginning on each January 1st, or until relieved by the Board selected for the ensuing year, and shall reorganize each year on or about that date.

ARTICLE IV

OFFICERS

SECTION 1. The officers of the Federation shall be a Chairman, Vice-Chairman, Secretary-Treasurer and Editor, as provided in Article IV, Section 2, of the Constitution. The Chairman and Vice-Chairman shall be selected at the annual meeting from the membership of the Board, by a majority vote of the members attending the annual meeting. They shall serve without compensation and their tenure of office shall be limited to one year, except as provided in Section 5 of this Article. The Secretary-Treasurer and Editor, either one of whom may or may not be a member of the Board, shall be selected by the Board and may receive compensation, the amount of which shall be determined by a two-thirds vote of the full Board. The Secretary-Treasurer and Editor shall be selected by a majority vote of the full Board, as determined by letter ballot, to be conducted by the Chairman, and shall be appointed and removed under regulations to be prescribed by the Board, subject to the provisions of Sections 3 and 4 of this Article.

SEC. 2. The Chairman, in addition to his ordinary duties, shall countersign all bills and vouchers before payment and shall present an annual report of the transactions of the Board, which report, together with a synopsis of the general transactions of the Board, of interest to members, shall be published in the Journal of the Federation. The Vice-Chairman shall perform any or all of the duties of the Chairman whenever the latter may be unable, for any reason, to perform them.

SEC. 3. The Secretary-Treasurer shall be the active business agent of the Board and shall be appointed for a term of two years unless removed for cause by the Board. He shall perform the ordinary duties both of a secretary and of a treasurer. He shall receive all dues, subscriptions and other monies paid to the Federation and shall hold or dispose of the same under such rules as the Board may prescribe. He shall certify the correctness of all bills before transmitting them to the Chairman for countersignature. He shall act as recorder of the Board and shall maintain a complete record of its transactions. He shall be permitted to select a Business Manager and such clerical and other assistants as may be necessary, under regulations to be prescribed by the Board.

SEC. 4. The Editor shall be the literary agent of the Board and shall be appointed for a term of three years, unless removed for cause by the Board. He shall receive all manuscript copy, prepare it for publication, and shall be responsible for the proof-reading, printing and mailing of the Journal of the Federation, except in so far as he may be relieved of such duties through other arrangements made by the Board. He shall have the power to return to the author for correction, or to reject entirely, any manuscript which may be in bad condition, illegible, or clearly deficient in respect to composition, subject matter or supporting data, or otherwise conspicuously deficient or unfit for publication. He also shall have the power to reject any technical manuscript which is designed to promote commercial interests. He may appoint such editorial or clerical assistants as he may desire, subject to conditions and regulations to be prescribed by the Board.

SEC. 5. The term of office of all officers of the Federation shall become effective immediately on their selection and acceptance of office and shall continue until their successors have been selected and duly qualified.

ARTICLE V

MEETINGS

SECTION 1. The Board shall meet annually in January as promptly as is practicable after the selection of the constituent members of the said Board. The date and place of the annual meeting shall be decided at the next prior meeting by a majority vote of the members of the Board attending the said prior meeting. Due notice of the date and place of such meeting shall be published in the Journal of the Federation and shall be sent by the Secretary-Treasurer to each member of the Board and to the Secretary of each member association at least fifteen days in advance of the scheduled date of the meeting.

SEC. 2. At any meeting of the Board, a quorum shall consist of two-thirds of the duly selected members thereof. Absent members may vote by proxy, all such proxies being counted in determining a quorum.

SEC. 3. The Board is hereby empowered to authorize payment, by the Federation, of the traveling expenses of the Secretary-Treasurer to attend the Annual Meeting.

ARTICLE VI

COMMITTEES

SECTION 1. The Board shall select, at its annual meeting, from among its members, an Executive Committee, consisting of the Chairman, Vice-Chairman, two other members and the Secretary-Treasurer as an ex-officio member; a Membership Committee, consisting of three members, a Publication Committee, consisting of five members, the Editor to be ex-officio member thereof; a Coördination Committee, consisting of three members; and a Research Committee, consisting of five members. The Chairman of the Federation shall be Chairman of the Executive Committee, and the Board shall designate the officers of the other committees.

SEC. 2. The Executive Committee shall have full control of the management of the affairs of the Federation between meetings of the Board, subject to such actions as may be passed by the Board at its meetings. A special meeting of the Executive Committee may be called by the Chairman whenever necessary, due notice of the time and place of such meeting being given to members of the Committee by the Secretary-Treasurer. The Executive Committee shall present at each annual meeting of the Federation a budget of estimated expenses of the Federation, including those of publications, during the ensuing year. On adoption of the budget by a majority vote of the Board, the expenses of the Federation shall be limited as far as may be practicable, within the amounts prescribed in the said budget.

SEC. 3. The Membership Committee shall be charged with the duty of passing on applications for membership in the Federation and also with the encouragement of the formation of new local, state or district associations or conferences eligible for membership in the Federation. Special meetings of the Membership Committee may be called by the Chairman of the said committee whenever necessary.

SEC. 4. The Publication Committee shall have full charge, except for questions involving finances, of the policies of the Board relative to any publications for which the Federation may be responsible.

SEC. 5. The Coördination Committee shall be charged with the duty of assisting in the coördination of activities of the various member associations, aside from research work.

SEC. 6. The Research Committee shall be charged with the duty of stimulating and coördinating research work among the various member associations and of coöperating with other organizations in the promotion of research work.

SEC. 7. The Board shall have full power to fill vacancies occurring in any office or in any of the aforesaid committees, and to form such temporary committees as may be deemed desirable.

ARTICLE VII

PUBLICATIONS

SECTION 1. Each member association shall forward its papers and transactions to the Editor with its recommendations as to publication, and for this purpose may appoint its association editor or editorial committee. Papers submitted by individuals may be accepted for publication at the discretion of the Editor.

SEC. 2. The official publication of the Federation shall be a Journal, as herein designated, which shall be published under the general supervision of the Publication Committee and under rules and arrangements prescribed from time to time by the Board, acting on recommendations by the Publication Committee. The name of the Journal shall be determined by a two-thirds vote of the Board, acting on recommendations by the Publication Committee.

SEC. 3. Each member association shall notify the Editor of the Federation as to the minimum number of copies of the Journal which it desires to receive and shall furnish a certified mailing list for the same from time to time. Copies ordered by any member association shall be distributed to the individual members of such association, in accordance with rules to be adopted by a majority of the Board.

SEC. 4. The publications of the Federation, including the Journal, shall be open to public subscription and sale, at prices to be fixed from time to time by a two-thirds vote of the Board. Additional copies of the Journal, for the use of member associations, may be purchased by them at cost or at a nominal price, to be fixed by a two-thirds vote of the Board. Advertisements of an appropriate character shall be received under regulations to be prescribed by a majority of the full Board.

SEC. 5. If the total revenues received by the Federation, including dues, as prescribed in Article II of these By-Laws, and income from advertisements in the Journal, should be insufficient to cover the expense of publishing the Journal during a given year, the deficit may be balanced by means of a special assessment, to be proportioned among the member associations in accordance with the relative average number of copies of the Journal supplied to each respective member association and individual members thereof, or by such other means as may be determined by a two-thirds vote of the full Board, having due regard for the budget limitations prescribed in Article VI, Section 2, of these By-Laws.

SEC. 6. If a manuscript submitted by a member association for publication in the Journal should be rejected by the Editor, in accordance with Article IV, Section 4, of these By-Laws, the question of its acceptance may, on application of the member association from which it has been received, be reviewed by the Publication Committee, on whose recommendation the Board, by a two-thirds vote of the full membership, may order its publication if it appears to them desirable.

SEC. 7. The Board shall have authority to print in the Journal such abstracts and translations from scientific and professional journals and society transactions as may be deemed of general interest and value, and be recommended by the Editor.

ARTICLE VIII

AMENDMENTS

Amendments to these By-Laws may be made by a two-thirds vote of the members of the Board present at any annual meeting, notice of the proposed amendment having been given to the member associations not less than sixty days in advance of the said meeting.

Sewage Research

The Effect of Age of Sewage Solids upon Their Digestibility

By Gordon M. Fair[1] and Louis Klein[2]

In Imhoff tanks the fresh sewage solids, immediately upon settling, slide from the sedimentation compartment into the underlying digestion chamber. Here they encounter well-ripened sludge in large volume, a fact that carries with it two seemingly outstanding advantages as far as subsequent digestion of the fresh solids is concerned. (1) The fresh solids at once become inoculated with the bacteria and ferments associated with good sludge digestion. (2) The fresh solids immediately become mixed with highly-buffered alkaline sludge capable of maintaining the hydrogen-ion concentration of the mixture at or above pH 6.8, a value at which rapid digestion seems to result.

Separate sludge-digestion tanks, on the other hand, do not receive fresh solids immediately upon their deposition in the sedimentation basins that the digestion tanks serve. Depending upon the method used for the removal of sludge from the sedimentation basins, varying intervals of time will elapse before the solids are introduced into the digestion tank. The time elapsed may be a matter of hours only, but is often a matter of days. Even with so-called continuous sludge removal by mechanical devices, a suitable depth of sludge must be maintained on the bottom of the sedimentation tank in order to facilitate the withdrawal of a sludge containing as little water as possible. The sludge therefore is seldom strictly fresh.

The question arises whether it is actually essential to rapid and good digestion that the settling solids reach the digestion tanks in as fresh a state as possible and, if so, just what will be the effect of allowing sewage solids to accumulate for varying periods of time before mixing them with ripening sludge. The authors, knowing of no published work that gives a direct answer to this question, have undertaken experiments with two different sewages, one, Fitchburg, Mass., sewage, of more or less domestic origin, the other, Brockton, Mass., sewage, which carries appreciable amounts of trade wastes from leather-working industries.

Experimental Technique.—The character of the settled solids collected by suspending pails in the settling tanks for 24 hours is indicated by the

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[2] *Research Assistant in Sanitary Engineering, Harvard University, Cambridge, Mass.*

analyses shown in the accompanying table. Analyses of the well-digested sludge with which the fresh solids were subsequently seeded are also included in this table.

TABLE I

ANALYSES OF SEWAGE SOLIDS

	Fresh Solids		Digested Solids
	Fitchburg	Brockton	Fitchburg
Per cent solid matter	5.1	5.7	16.9
Per cent water	94.9	94.8	83.1
Per cent loss on ignition	63.3	84.4	47.0
pH	5.5	5.0	6.9

It is obvious, from an examination of these results, that the Brockton solids are very different from the Fitchburg solids.

The freshly collected solids after standing at a temperature of 20° C. for varying intervals of time were mixed with well-digested sludge in a ratio of about 2 parts of fresh organic material to 1 part of digested organic material. The mixtures were kept at 20° C. after being placed in sealed glass bottles equipped so that the gases of digestion could be collected and the changes in hydrogen-ion concentration could be observed. (For a description of the author's experimental technique see *Journal Boston Society of Civil Engineers*, **14,** 84 (1927), and *Engineering News-Record*, **99,** 881 (1927).)

The manner in which the solids digested after being seeded with ripe sludge is shown in Figs. 1 (Fitchburg) and 4 (Brockton) by the production of methane gas and in Figs. 2 (Fitchburg) and 5 (Brockton) by the variations in hydrogen-ion concentration as measured by the pH values of the mixtures.

Studies with Fitchburg Sewage.—Turning first to Fig. 1, which shows the cumulative methane production of the Fitchburg sewage, it is seen that the solids that had stood for but one day gasified rapidly and were apparently well digested at the end of 9 weeks. By this time they had produced over 400 liters of methane per kilogram of fresh organic (volatile) solids. As shown in Fig. 2, the pH of this batch passed the neutral point in 4 weeks. Almost as rapid was the progress of the sludge that had been left unseeded for 6 days. Four hundred liters of methane were given off in 9 weeks and pH 7.0 was passed during the 6th week. The behavior of the solids that had not stood as long was not nearly so good. For the 2-day solids, 21 weeks elapsed before an equal amount of methane was produced and 8 weeks before pH 7.0 was permanently passed. The 4-day solids were even more sluggish, neutrality not being established until the 27th week and only 260 liters of methane having been captured when the run was discontinued after 28 weeks. Beyond the 6th day, the 10-day batch behaved somewhat like the 4-day solids while the 17-day batch

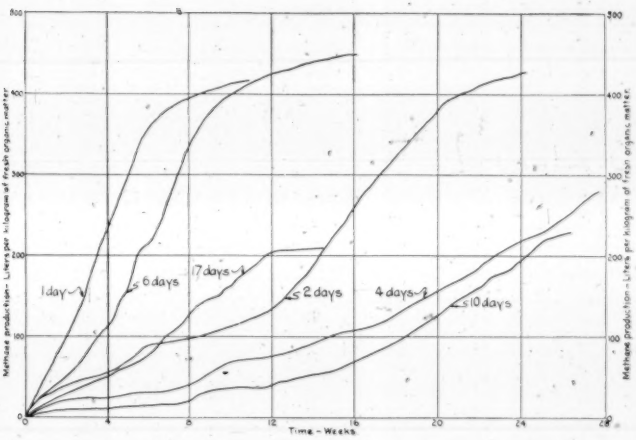

FIG. 1.—Methane Production by Fitchburg Sewage Solids during Digestion.

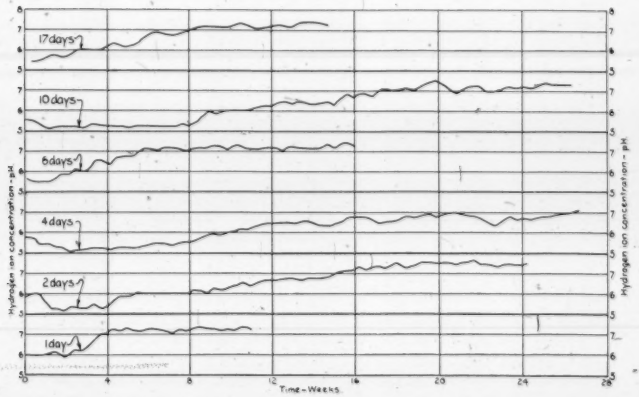

FIG. 2.—Variation in Hydrogen-Ion Concentration by Fitchburg Sewage Solids during Digestion.

at one time showed better results than the 2-day solids, but sloughed off after the 12th week.

In all cases marked correlation was observed between methane production and hydrogen-ion concentration. It has been thought worth while to bring out this fact more clearly in Fig. 3. Here the time required to produce certain quantities of methane and pass certain pH values has been plotted for the different batches.

Studies with Brockton Sewage.—That it is dangerous to assume that the solids settled from other sewages necessarily act in the same way as did the Fitchburg solids is shown by examining the results obtained with Brockton sludge. The digestion of these solids, which are richer in manu-

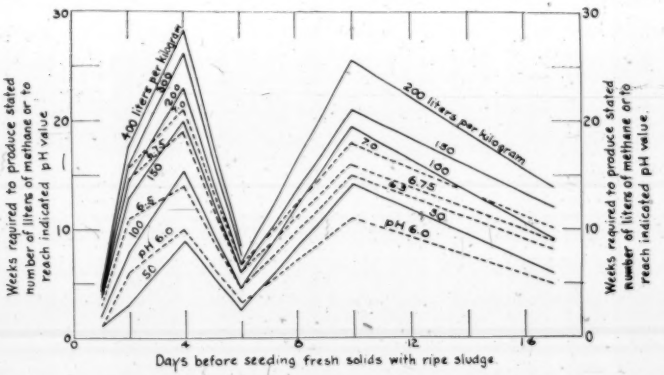

FIG. 3.—Correlation between Methane Production and Hydrogen-Ion Concentration of Fitchburg Sewage Solids during Digestion.

facturing wastes, gives quite another picture. Unfortunately the exigencies of experimentation did not permit the use of 1-day sludge. As shown in Figs. 4 and 5, all batches digested far more slowly than did the Fitchburg solids. The two batches (3- and 7-day) in which good digestion became established, however, yielded somewhat higher methane totals than were obtained with Fitchburg material. Of the various runs, the 7-day solids produced 400 liters of methane per kilogram of fresh organic matter in 20½ weeks, after passing pH 7.0 during the 16th week. The corresponding time values for the 3-day solids are 25 and 18 weeks, respectively. The remaining batches (2-, 5-, 11- and 18-day batches) gasified but slightly during the 20 or more weeks of experimentation and remained consistently acid during this time. All results obtained show the influence of waste matters that do not yield readily to the desirable alkaline or methane fer-

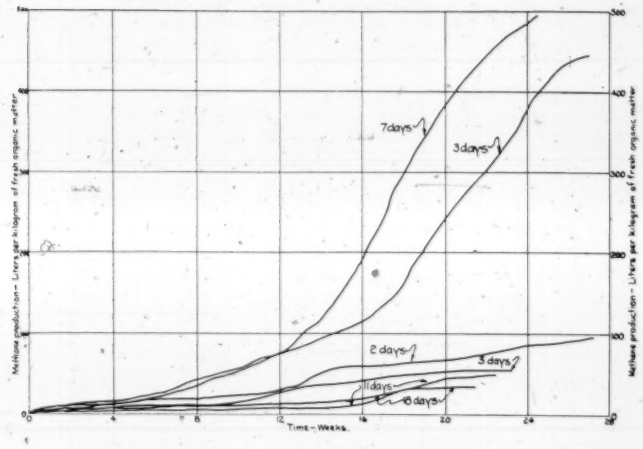

FIG. 4.—Methane Production by Brockton Sewage Solids during Digestion.

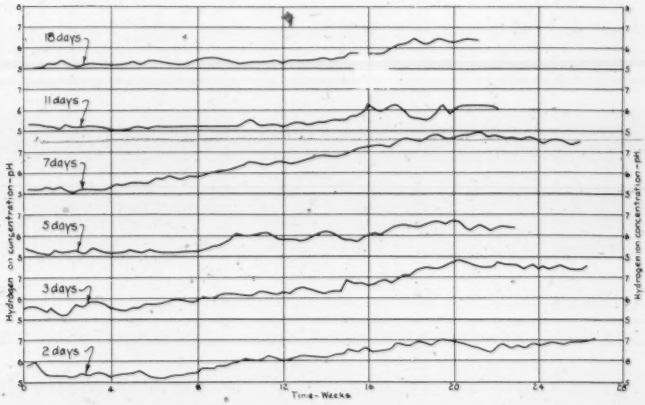

FIG. 5.—Variation in Hydrogen-Ion Concentration of Brockton Sewage Solids during Digestion.

mentation. Large-scale experiments by the City of Brockton, some years ago, showed that the Brockton sludge would not digest satisfactorily in an experimental Imhoff tank. The authors have shown (*loc. cit.*), however, that by suitable adjustment of the hydrogen-ion concentration of Brockton sludge this unruly behavior can readily be overcome.

Conclusions.—Recognizing the limitation of laboratory experiments, the results obtained in these two series of tests, with widely divergent types of sewages, may serve as evidence upon which can be based a tentative answer to the introductory question regarding the effect upon subsequent digestion of allowing sewage solids to accumulate before they are seeded with ripe sludge. This answer may be formulated as follows: There is seemingly no regular and progressive deterioration of the digestibility of fresh sewage solids that are left unseeded. Their behavior is different during various intervals of time. In the absence of interfering industrial wastes, however, it seems desirable that the settling solids reach the digestion tanks as soon as possible, even though at certain periods of decomposition unseeded material will digest very readily. In the presence of certain trade wastes or other modifying factors digestion may proceed better if the solids remain unseeded for a limited number of days. The authors' previous experience with Brockton sludge, however, leads them to believe that "liming" or other suitable pH adjustment of the fresh solids will be more advantageous.

Where pH adjustment cannot readily be applied and plant operation shows that digestion is poor, variation of the interval of time allowed to elapse between sludge collection and introduction of the solids into digestion tanks should be studied.

In closing, the authors wish to acknowledge the assistance of Messrs. H. B. Allen and F. W. Kennedy, chemists in charge of the Fitchburg and Brockton Sewage Disposal Plants, respectively.

Composition and Decomposition of Fresh Sewage Solids Collected from Different Parts of a Settling Tank[1]

BY H. HEUKELEKIAN[2]

The influence of design of a settling tank upon the rate of removal of suspended solids from sewage has been well appreciated, although all the controlling factors are not fully known. The method of operation of the

[1] *Paper No. 71, Department of Sewage Disposal, N. J. Agricultural Experiment Station, New Brunswick, N. J.*

[2] *Research Bacteriologist, New Jersey Sewage Experiment Station.*

tanks and the character of sewage determine the total removal of suspended solids, but the composition of solids removed at the inlet end may be quite different from those settling at the outlet end. It is reasonable to assume that there may be more or less complete classification or grading of the settling particles on account of a differential rate of settling. The effect of such grading of particles on the rate of digestion and subsequent capacity of the tank is not known.

The studies reported here are the continuation of the report of our research on the cellulose content of fresh solids collected from different compartments of an Imhoff tank.[3] Our results indicated that there were very marked and significant differences in the cellulose content of the solids deposited at the inlet and outlet ends of the tank. Fresh solids from the inlet end had the highest cellulose content (9.7% on the basis of volatile matter) while those from the middle and the outlet had considerably less (4.3% and 3.7%, respectively). It was thought of interest to find out whether there were similar differences in the nitrogen and fat content of settled solids, also to determine the effect these differences in composition might have on the course of decomposition.

EXPERIMENTAL PROCEDURE

Fresh solids were collected from the Imhoff tanks at Plainfield which were used at the time as plain sedimentation tanks. The pails were sunk in the inlet, middle and outlet end of the flow chamber inside of the baffles. The mixture, unless otherwise stated, was made by mixing the contents of the individual pails after the necessary samples were taken. Solids were incubated in bottles at 60–70° F. in the laboratory at New Brunswick.

The fat and nitrogen determinations were made on the dried samples. Fat extractions were made with petroleum ether for 8–10 hours. Total nitrogen determinations were made by the Kjeldahl method. All other determinations were made according to methods described in previous publications from this laboratory.

RESULTS

Fat and Nitrogen Content of Fresh Solids Settling in Different Parts of the Tank

In Table I are given the results of fat and nitrogen content of four samples collected between Dec. 8, 1927, and Feb. 29, 1928. All samples had a uniform ash content of about 20 per cent and hence these figures are not included in the table.

Fat and grease constituted from one-third to one-half of the volatile matter of the solids depending on the end of the tank from which they

[3] *Public Works*, April, 1927.

TABLE I

FAT AND NITROGEN CONTENT OF FRESH SOLIDS SETTLING IN DIFFERENT PARTS OF THE TANK (PER CENT ON BASIS OF DRY VOLATILE MATTER)

	Dec. 8		Jan. 4		Jan. 10		Feb. 29	
	Fat	N	Fat	N	Fat	N	Fat	N
Inlet	31.4	4.41	38.5	3.57	32.0	3.20	51.5	4.23
Middle	49.7	5.27	37.3	3.71	52.8	3.84	53.7	4.40
Outlet	51.5	4.75	48.7	4.16	52.3	3.96	55.1	4.81
Mixture	43.2	4.72	51.4	3.84	47.3	3.74	51.5	4.53

were taken. The fat content of the material from the inlet end was lowest in all samples. With the exception of the sample obtained on February 29th there was a considerable increase of fat in the samples from the outlet compartment. There was not much difference between the middle and outlet end, with the exception of the January 4th sample.

It appears from these results that fats which are in a state of emulsion settle at a slower rate than the coarse fibrous substances. Results indicate that the fats settled at about the same rate in the middle and the outlet end. There is no decrease in the percentage of fat in solids from the outlet end, indicating that possibly under the conditions of operation some of the fats were passing out of the tank.

In a similar way the nitrogen content of the material from the inlet end is the lowest in all cases. These results check our former statements that the coarser particles settling at the inlet end are non-nitrogenous in character. With the exception of one sample, namely, that of Dec. 8th, the material from the outlet end had the highest nitrogen content, but the increase of nitrogen is in general not as great as the increase of fat.

These results indicate that the design of a settling tank may determine the composition of settled solids, which can be deposited in more or less well defined zones if this should prove to be advantageous for subsequent digestion of the solids *in situ*. It would not be the case if the settled solids were to be pumped into separate sludge digestion tanks.

The digestion experiments recorded below were conducted to determine whether the digestion of these segregated solids would proceed at a greater rate than if they were mixed.

Digestion of Solids from Inlet, Middle and Outlet End of a Settling Tank

A sample of fresh solids was taken from the inlet and outlet end of the tanks at Plainfield; the material from the inlet end was diluted with water to the same solid concentration as that from the outlet and the two materials were allowed to digest.

Unseeded Solids.—The pH values of the materials obtained during the course of digestion are plotted in Fig. 1. The curve for the pH value of fresh solids from the inlet end demonstrates the usual phenomena that

occur when fresh solids are digested without seeding. There was a rapid fall of pH values to 5.2, a prolonged period in which the pH value was stationary, then a gradual increase to the neutral point and finally up to

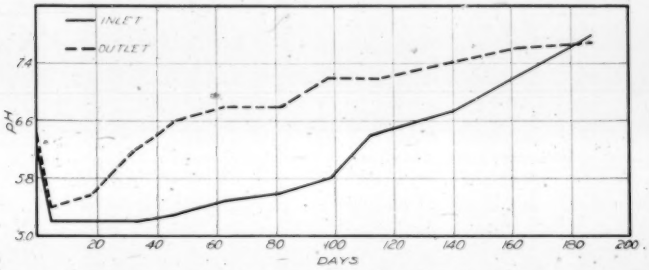

FIG. 1.—Comparison of the pH Values in the Course of Digestion of Fresh Solids Collected from the Inlet and Outlet Compartments of the Tank.

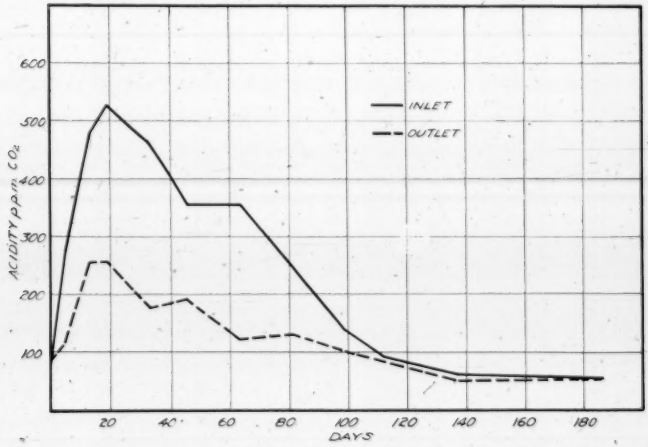

FIG. 2.—Comparison of the Acidity Produced in the Course of Digestion of Fresh Solids Collected from the Inlet and Outlet Compartments of the Tank.

7.6–7.8 when digestion was complete. The picture is a different one with the material from the outlet end. The rapid drop took place though not to as low a point as usual, but immediately after the minimum was reached the

pH value climbed rather rapidly and within five weeks the original pH value was regained, whereas it took about 15 weeks for the material from the inlet end to regain its original value. The neutral point was reached by the inlet sludge in 5 months and by the outlet sludge in 3 months.

The acidity (to phenolphthalein) of the material from the inlet end increased rapidly within the first 3 weeks, after which it decreased gradually and within 4 months it had dropped back to a low level (Fig. 2). The material from the outlet end demonstrated the same type of phenomenon with the exception that its maximum acidity was only about half as great. The alkalinity curve (to methyl orange) for the material from the outlet end was considerably higher throughout the period of digestion than that of the inlet end (Fig. 3). The latter remained stationary for a long period after the initial increase, whereas the alkalinity in the former increased consistently throughout the duration of the experiment.

TABLE II

SOLIDS AND ASH CONTENT OF UNSEEDED SOLIDS FROM THE INLET AND OUTLET END OF AN IMHOFF TANK

	Inlet			Outlet		
Days Digested	Solids %	Ash %	Reduction Vol. Matter %	Solids %	Ash %	Reduction Vol. Matter %
0	2.17	17.5	..	2.30	20.0	..
5	2.16	18.1	1.7	2.17	22.1	8.1
13	1.80	19.5	18.9	2.07	22.7	13.0
19	1.68	20.3	25.1	2.03	22.9	15.2
33	1.69	24.3*	..	1.88	26.6	25.0
46	1.57*	23.1*	..	1.81	26.0	27.1
63	1.68	21.5	26.2	1.85	25.4	25.0
81	1.68	21.4	26.8	1.87	25.7	24.4
98	1.57	21.7	31.3	1.75	26.7	30.4
112	1.87*	23.7	..	1.61	28.7	38.0
137	1.46	23.2	37.4	1.31	32.5	52.2
161	1.37	28.2	45.2	1.38	35.2	51.6
187	0.91	31.8	65.3	1.16	39.2	62.0

* Left out of curves on account of irregularity.

Results of analyses for solids and ash are given in Table II. Increase of ash content and decrease of solids during digestion are shown in Fig. 4 in per cent of the initial values. The differences in reduction of solids between the materials from the inlet and outlet end are small and probably of no significance. However, the material from the outlet end indicates a greater percentage ash increase than that from the inlet end, and this difference becomes more marked toward the end of digestion. The per cent reduction of volatile matter (Table II) is eventually about the same for the two materials.

These results indicate that the time of digestion of unseeded material

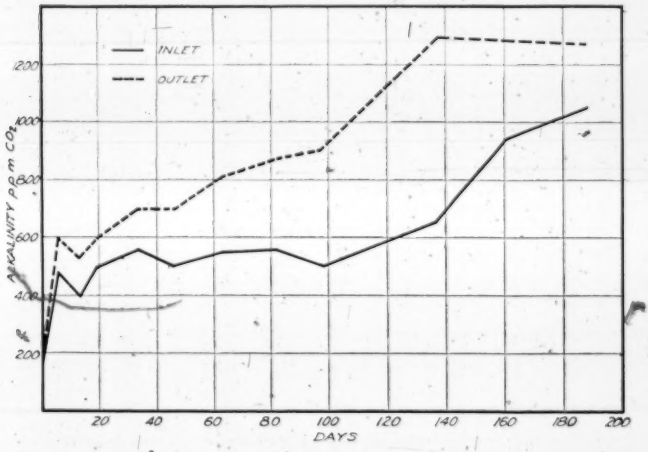

FIG. 3.—Comparison of the Alkalinity in the Course of Digestion of Fresh Solids Collected from the Inlet and Outlet Compartments of the Tank.

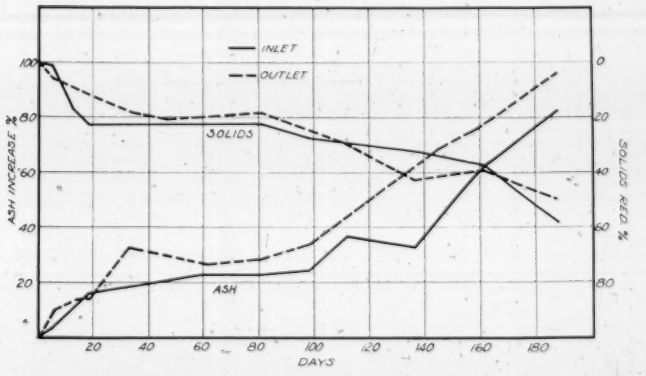

FIG. 4.—Solids Reduction and Ash Increase in the Course of Digestion of Fresh Solids Collected from the Inlet and Outlet Compartments of the Tank.

from the outlet end was about two or three months ahead of the material from the inlet end. The retardation in the latter is especially marked in the early period when cellulose digestion takes place. It would seem that the high percentage of cellulose in the material from the inlet end contributed to this retardation by giving rise to a higher acidity.

Seeded Solids—First Experiment.—The differences noted in the above experiments are exaggerated because there was no seeding material added. To approximate the actual conditions in a tank a series of experiments was started in which the materials from the inlet, middle and outlet end, and a mixture of these, were all properly seeded (2 fresh : 1 ripe on the basis of volatile matter). The mixtures were incubated at 70° F. The temperature in the incubator dropped down to 60° F. on a few occasions.

Table III gives the reduction of volatile matter, the total volume of gas produced, the number of days elapsed before the peak of gas production was over and the percentages of fat and nitrogen in the fresh solids of the inlet, middle, outlet, and of the mixture.

TABLE III

FIRST EXPERIMENT. DIGESTION OF SEEDED MATERIALS FROM DIFFERENT PARTS OF A SETTLING TANK

	Inlet	Middle	Outlet	Mixture
Per cent reduction of volatile matter (47 days)	46.4	47.4	46.0	48.0
Gas produced in 24 days*	550	480	625	446
Gas produced in 30 days*	715	705	750	660
Gas produced in 47 days*	817	855	845	800
Days elapsed before the peak of gas production was over	24	28	23	29
Per cent fat in raw volatile matter	32.0	52.8	52.3	47.3
Per cent nitrogen in raw volatile matter	3.20	3.84	3.96	3.74

* Gas figures expressed as cubic centimeters per gram of volatile matter in fresh solids.

The reduction of volatile matter at the end of the experiment was about the same for the four samples. There may have been individual variations during the course of digestion but the bottles could not be opened for solids determinations while the experiment was in progress because of the effect of air on subsequent gas production.

The *total volume* of gas produced per gram of volatile matter introduced in fresh solids was highest for the material from the middle and outlet, but the differences were not great and might have been within the experimental error. There were wide differences, however, in the *rate* of gas production (Fig. 5). Whereas the material from the outlet gave the

highest rate of gas production the material from the middle had a slow rate in spite of the fact that these two materials had nearly the same fat content. The difference cannot be explained on the basis of fineness of division since the material from the inlet end, with considerable amounts of coarse particles, gasified more rapidly than the material from the middle, which was more finely divided and similar to the material from the outlet end. The mixture of solids from all compartments gave both the lowest yield of gas and the slowest rate of gasification. This fact would indicate that classified or graded solids digest more rapidly than total settled solids intimately

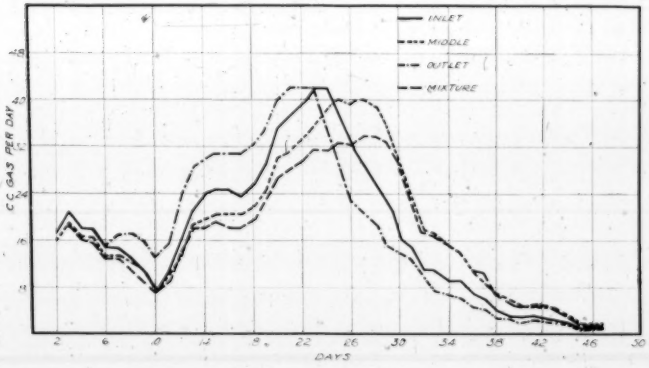

FIG. 5.—Comparison of Daily Rate of Gas Production in the Course of Digestion of Seeded Fresh Solids Collected from the Inlet, Middle, Outlet and Mixture. (Cc. per Gram of Volatile Matter Added, Moving Average of Three). First Experiment.

mixed. The reason for the slow rate of gasification of the material from the middle may be explained in a similar way, namely, because of the heterogeneous character of the settled material.

Seeded Solids—Second Experiment.—To check the above results the experiment was repeated with a different lot of fresh solids. The conditions of the experiment were as far as possible identical with the previous ones. The solids were collected on the same day of the week as before. The seeding was in the ratio of 2 fresh : 1 ripe on the basis of volatile matter. Results of the second experiment are shown in Table IV and Fig. 6.

The differences in the condition of the two experiments were as follows:

(1) A comparison of results in Tables III and IV indicates that solids from the inlet end had a fat content of 32.0 per cent in the first experiment and 51.5 per cent in the second.

TABLE IV

SECOND EXPERIMENT. DIGESTION OF SEEDED MATERIALS FROM DIFFERENT PARTS OF A SETTLING TANK

	Inlet	Middle	Outlet	Mixture
Per cent reduction of volatile matter (37 days)	43.4	45.6	43.8	53.6
Gas produced in 10 days*	287	266	282	256
Gas produced in 18 days*	665	610	635	580
Gas produced in 37 days*	890	885	825	790
Days elapsed before the peak of gas production was over	15	20	15	18
Per cent fat in raw volatile matter	51.5	53.7	55.1	51.5
Per cent nitrogen in raw volatile matter	4.23	4.40	4.81	4.53

* Gas figures expressed as cubic centimeters per gram of raw volatile matter added.

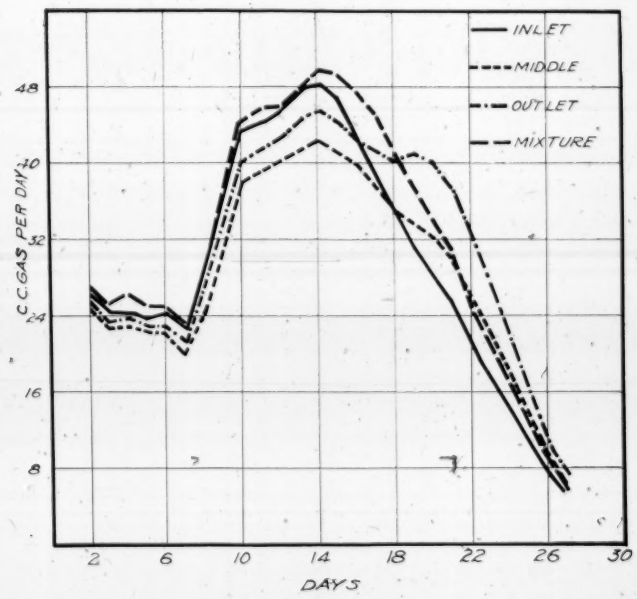

FIG. 6.—Comparison of Daily Rate of Gas Production in the Course of Digestion of Seeded Fresh Solids Collected from Inlet, Middle, Outlet and Mixture (Cc. per Gram of Volatile Matter Added, Moving Average of Three). Second Experiment.

(2) In both cases each bottle received the same amount of fresh solids and was seeded with the proper amounts of ripe sludge, but in the first series all sludge mixtures were made up to the same concentration by the addition of water and in the second experiment no attempt was made to have equal concentration of solids. Such small variations in the solids concentration should not have an appreciable effect on sludge digestion.

(3) The mixture in the second experiment was prepared by mixing materials from inlet, middle and outlet on the basis of equal weights of volatile matter while in the first experiment equal amounts of solids from each compartment were mixed without regard for the content of volatile matter.

(4) Temperature control at 70° F. was more uniform in the second experiment.

It is apparent that the digestion proceeded much more uniformly and rapidly in the second test, without the retardations caused by low temperatures which occurred in the first experiment. The digestion was completed in the second experiment at least ten days earlier than in the first one. This rapidity of digestion masked the variations in gas production to some extent in the second experiment.

The reduction of volatile matter was nearly alike for all samples in Series 2 with the exception of the mixture of the three materials where a noticeably higher reduction of volatile matter took place in spite of the fact that the least amount of gas was produced per gram of raw volatile matter added (Table IV). This phenomenon of low gas yields with high volatile matter reduction has been encountered time and again and will be dealt with in a future publication.

The total yield of gas was equally high for the inlet and middle compartments, lower for the outlet sample and lowest for the mixture. Apparently gas production is not correlated with the fat content of the solids because the material from the outlet had a somewhat higher fat content and gave lower gas production than the material from the inlet.

The *rate* of gas production was highest for the material from the inlet end, followed by the outlet and middle, and finally by the mixture. It took about 15 days for the material from the inlet and outlet ends to pass the peak of gas production and 18–20 days for the materials from the middle and the mixture.

DISCUSSION

The second series brings out essentially the same conclusion as the first, namely that the *total yield* of gas is not correlated with the fat content of the sludge. The *rate* of gas production seems to be correlated with the heterogeneous or segregated character of the settled material. The mixture of solids from all compartments digested more slowly and produced

less gas than the material from the individual compartments. There may be two explanations for these phenomena:

When a mixture of substances of variable composition is decomposed there may be produced intermediate or end products which are inimical to the further decomposition of a particular substance. For instance, in the case of the decomposition of carbonaceous compounds, fatty acids are produced which retard the rate of decomposition of nitrogenous compounds. It is only after these acids are neutralized or broken down that the decomposition of nitrogenous compounds proceeds at a rapid rate.

The second possibility is that there is an optimum condition for the decomposition of each type of substance. The decomposition of certain carbonaceous materials may, for instance, proceed more rapidly at a slightly acid reaction. The organisms decomposing these substances will be more numerous and more active when the conditions for their activities are at an optimum. When solids of variable composition are mixed the conditions, both chemical and biological, are not likely to be the optimum for any component of the mixture.

It is well to note again the influence of temperature and proper seeding on the rate of gas production of the materials from the different compartments. Retardation of gas production is not so marked when the conditions for digestion are ideal, namely with proper seeding and temperature control. On the other hand, when the material is poorly seeded and the temperature is low the retardation will be more accentuated. The greater the heterogeneity of the materials the greater the effect will be.

The results above reported in regard to the rate of settling of the different components of sewage may be somewhat modified with a different sewage; with a tank of a different design; and under different operating conditions. More work should be done to determine the effect of these factors, especially the effect of the velocity of flow and the differential rate of settling.

SUMMARY AND CONCLUSIONS

Studies have been conducted to determine the composition of settled solids from the inlet, middle and outlet of the flow chamber of Imhoff tanks in Plainfield. The digestion of solids from different compartments of the tank has been studied under laboratory conditions. The following general conclusions may be drawn from the results presented:

1. The solids settling at the inlet end of a tank have a higher percentage of cellulosic substances (previously reported) and smaller percentage of fats and nitrogenous substances.

2. The middle and outlet end of a tank receive solids containing comparatively high percentages of fat and nitrogen. There is no decrease in the fat content at the outlet as compared with the middle and conceivably considerable amounts of the fats pass out of the tank.

3. Certain factors such as differences in the composition of sewage may affect the rates of settling noted above.

4. In the digestion of unseeded materials a shorter period of acid digestion, higher alkalinity and higher ash increase was obtained for the material from the outlet than from the inlet end.

5. The seeded solids from the inlet and outlet ends produced gas more rapidly than solids from the middle or a mixture from all parts of the tank.

6. A high fat content is not always correlated with high yield of gas.

7. The mixture of solids settling in inlet, middle and outlet compartments had the lowest gas yield and the lowest rate of gas production.

8. The slow rate of gas production for solids from the middle compartment and the mixture may be due to the more heterogeneous nature of the settled solids.

Comments on Methods for Determination of Residual Chlorine[1]

BY LINN H. ENSLOW[2]

Control of the quantity of chlorine applied to water or sewage is no longer entirely dependent on bacteriological examinations. Where no control previously existed the "residual" method of dosage control has placed chlorination on a scientific basis.

"Residual chlorine control" is the term applied to the practice of introducing just sufficient chlorine into the water or sewage which will leave, within prescribed limits of time, a minute quantity of available—"residual"—chlorine. Such control is practiced to insure that the chlorine demand of the substances in solution has been satisfied and also for the purpose of avoiding overtreatment. Maintenance of this slight residual insures effective and continuous removal of disease-producing bacteria.

This paper includes discussion of four well-known methods of determining residual chlorine:

(*a*) The Starch-Iodide Titration Method.
(*b*) The Starch-Iodide Colorimetric Method.
(*c*) The Benzidene Hydrochloride Method.
(*d*) The Ortho-Tolidin Method.

(*a*) *The Starch-Iodide Titration:*

This old and well-known method is very accurate when employed in the absence of interfering substances.

[1] *Presented at the Second Annual Meeting of the Maryland Water and Sewerage Assoc., Baltimore, Md., April 10, 1928.*

[2] *Research Engineer, The Chlorine Institute, Inc., New York City.*

As early as 1902 Dr. M. Duyk[1]* at Middlekerke, Belgium, used starch-iodide titrations on filtered water which had been pre-chlorinated and treated with ferric chloride as a coagulant. The hypochlorite application was regulated through use of this test.

The presence of ferric iron compounds, nitrites or manganic compounds will cause misleading results.

The determination of the proper "end-point" in titration of samples low in residual chlorine is difficult. The blue color produced by addition of starch and potassium iodide solutions to the sample frequently returns quickly after it has been destroyed by titration. Thus, the method is likely to give uncertain results.

It should also be noted here that an investigation of sewage chlorination control by Tiedeman[2] indicated that the starch-iodide titration method indicates chlorine which is not in a readily available state. This conclusion was drawn from the fact that residual chlorine indicated by the acid starch-iodide titration method was not in [illegible] the ortho-tolidin test. In such instances long periods of c[illegible] required to kill *Bact. coli* in the sewage. On the other han[illegible] slight, but positive, test with ortho-tolidin was secured th[illegible] as effective in a shorter time. The titration method in m[illegible] gave residuals several times greater than were secured with o[illegible]

In connection with unpublished studies by Dr. [illegible] W. Mohlman, E. Hurwitz and C. C. Ruchhoft of the Sanitary District of Chicago, neutral starch-iodide tests indicated residuals on the average three times those secured with ortho-tolidin. The bacterial results indicated that a relatively high residual by starch-iodide and long contact were required for efficient disinfection, whereas a slight residual by ortho-tolidin produced almost immediate disinfection.

In other instances, including the work of Scott and Poole[3] at Bridgeport, Conn., it appears that the residual indicated by the starch-iodide test in the absence of acid and the ortho-tolidin test indicate approximately the same effectiveness of chlorination.

Tiedeman,[2] in the laboratory, compared simple chloramines, "Halozone" tablets (sulphon-dichlor-amino-benzoic acid), chlorine water and hypochlorite solutions. When chlorine or hypochlorite solutions were added to the sample, the results with starch-iodide and ortho-tolidin were identical. When chloramines or "Halozone" tablets were used, the starch-iodide method indicated a considerably higher residual than did the ortho-tolidin method.

On the whole it does not appear that the starch iodide test is a wholly reliable index of effective chlorination of sewage.

* Numbers in text refer to bibliography at end of article.

(b) *Starch-Iodide Colorimetric Determination:*

The previous remarks concerning the color development from chloro-compounds also apply in the case of the starch-iodide colorimetric determination.

In addition to the effect of ferric salts, manganic compounds and nitrites, this method has the serious disadvantage of being less delicate than other colorimetric methods. It is next to impossible to secure standard color solutions which will serve because of difficulties inherent in the materials themselves.

Olszewski[4] states that ordinarily less than 0.2 p. p. m. chlorine cannot be detected colorimetrically with starch-iodide, but that upon addition of 2 grams of potassium iodide and 5 cc. of 1% starch solution, 0.1 p. p. m. chlorine may be detected.

Buswell and Boruff[5] report that the most delicate test with starch-iodide is secured when to 50 cc. samples of water 0.75 gram of potassium iodide, 2 cc. C. P. hydrochloric acid and 1.5 cc. of 0.5% starch solution are added. With such proportions, 0.05 p. p. m. chlorine was detected. They also find that the color develops almost immediately at room temperature, remains constant for about 5 minutes and thereafter increases in intensity. At 23° C. the results are most nearly accurate. Increasing the temperature above 23° C. lessens the color intensity, while the colder the water the more intense is the color developed within five minutes. The alkalinity of the sample tested has some influence.

Howard[6] formerly employed the colorimetric starch-iodide test in plant control at Toronto, Ontario. More recently the ortho-tolidin method has replaced the starch-iodide procedure.

On the whole, the starch-iodide colorimetric method possesses disadvantages, not the least being the variability of colors produced and the difficulty of maintaining the reagents in good condition.

Olszewski[18] has recently suggested the addition of 4% caustic soda solution to a starch-iodide indicator solution containing 1% starch and 4% potassium iodide. The caustic is added until the starch solution is faintly alkaline to litmus, and thereafter the indicator apparently keeps well.

(c) *The Benzidene Hydrochloride Method:*

Olszewski[4] has perfected a colorimetric method employing a solution of benzidene in hydrochloric acid (Raschig's Solution). The reagent is prepared by grinding 40 grams of benzidene with 40 grams of water, adding approximately 750 cc. of water, 50 cc. C. P. hydrochloric acid and making up to 1000 cc. in a liter flask. The alkalinity of the water sample must be determined with methyl red indicator and the hydrogen-ion concentration adjusted to a pH value between 5.8 and 5.9 by addition of more acid or more water. To the adjusted sample is added that quantity of reagent

(Raschig's Solution) which will insure 1.6 to 2.0 mg. of benzidene per 100 cc. of sample. Production of a blue color indicates the presence of residual chlorine.

The test is sensitive to 0.02 p. p. m. residual chlorine, but, like the two preceding methods, it is influenced by the presence of manganic compounds. Iron does not interfere.

The chief advantages of the benzidene hydrochloride method are the distinct blue color and its sensitiveness.

The disadvantages lie in the technique required in determining the amount of acid to be added, the limited pH range required, and the necessity of adding fairly accurate amounts of benzidene. Excess reagent produces rapid decolorization. Excess acid causes the blue color to be changed to green, then to yellow. The reagent must be preserved in a dark place.

Olszewski and Radestock[18] have recently published formulae for preparation of various stock solutions of the benzidene indicator. Solution "A" is applicable to a water in a particular zone of alkalinity whereas solutions "B," "C," "D," etc., apply to waters of higher alkalinities. For "field" use such a scheme has its disadvantages.

Olszewski has developed a patented apparatus which automatically supplies acid and benzidene at intervals to the chlorinated water passing through glass jars. The equipment indicates the residual chlorine, but has no recording feature.

(*d*) *The Ortho-Tolidin Method:*

Prof. Earle B. Phelps[7] in 1909 first called attention to the use of ortho-tolidin as a reagent for detection of free chlorine in water. Prof. Kennicutt and F. W. Jones at the Worcester Polytechnic Institute in 1909 conducted experimental work with ortho-tolidin solutions. Seith of the Ohio State Department of Health (1913), without success, attempted use of acetic acid solutions of ortho-tolidin, but concluded that the method was of doubtful value.

Ellms and Hauser[8] perfected the ortho-tolidin method. Permanent standards were compounded and for the first time a satisfactory quantitative method of estimating chlorine colorimetrically was made available. Wolman and Enslow[9] were the first to make practical application of the test in the control of water chlorination. Muer and Hale[10] have proposed some modifications in preparation of the permanent standard solutions and the proportions of reagent to sample. The preparation of the 1% ortho-tolidin solution in 10% hydrochloric acid has always been a somewhat tedious procedure, until Theriault[11] recently published a much simplified method.

Recognition of the fact that in many respects a more acid solution of the ortho-tolidin reagent is desirable for use in connection with alkaline waters,

sewages or industrial wastes, has stimulated further study of the preparation of the ortho-tolidin reagent. By Theriault's method a solution containing 20% by volume of concentrated C. P. hydrochloric acid can be prepared, thus making available a solution having twice the acidity of the original Ellms and Hauser reagent. The advantages are that less of the reagent is required and a more constant tint of color is secured.

Because the procedure outlined in the Standard Methods of the A. P. H. A. could not be utilized in connection with turbid or colored waters, sewages, and the like, R. J. Morton[12] investigated modifications of the ortho-tolidin method for use in connection with sewages.

Tiedeman[2] successfully used small bottles in sewage studies at Huntington, L. I. The colors were compared with standards in similar bottles by transverse observations. Dana Kepner of Colorado, in a letter to the author (1926), suggested the use of oil bottles with "blanks" of the turbid material behind the standards, and transverse observations in comparing.

In 1927 the LaMotte Chemical Products Company perfected a "comparator" block set for determination of residual chlorine in turbid or colored samples, or liquids containing other interfering substances such as manganese, nitrites, etc.

The Wallace & Tiernan Co., Inc., has for several years sold a testing outfit for control of chlorination of water and swimming pools.

Comments on the Ortho-Tolidin Method

Oxidation of ortho-tolidin in acid solution will produce a yellow color. In the absence of other oxidative substances it becomes specific for chlorine.

Monfort[13] points out that bleaching powder (chlorinated lime) may contain chlorates, and water treated with such material is liable to produce a false color with ortho-tolidin because of the oxidative effect of the chlorates. This also applies when hypochlorite liquor from electrolytic cells is used.

Effect of Manganese

Manganous compounds do not affect ortho-tolidin but manganic compounds do, provided the compound be one of the hydrous oxides or permanganate. It does not appear that the sulfate, chloride or bicarbonate have any effect. Buswell and Boruff[5] chlorinated solutions of manganous sulfate which thereafter gave no false test with ortho-tolidin.

Forsberg[14] finds that 1 p. p. m. of manganese or manganic hydroxide in surface waters gives an indication of 0.2 to 0.25 p. p. m. available chlorine. Hopkins[15] points out that ortho-tolidin is a useful reagent for quantitative colorimetric determination of permanganate and also that practically all hydrous oxides of manganese other than pure manganous hydroxide will produce a yellow color with ortho-tolidin reagent. As little

as 0.07 p. p. m. manganese produces some color and in the form of permanganate of potash 1 p. p. m. produces a color intensity equal to 1 p. p. m. available chlorine. The color fades after 20 minutes.

In actual plant practice at the Baltimore filter plant, an average of approximately 0.7 p. p. m. manganese produced a color equivalent to approximately 0.15 p. p. m. chlorine in the raw water, which agrees with Forsberg's figures.

Effect of Iron

Ferric iron does not interfere with the accuracy of the ortho-tolidin test unless present to an extent sufficient to discolor the water. Buswell and Boruff conclude that iron present to the extent of 6 p. p. m. as ferric sulfate does not interfere. Forsberg found no interference from 10 p. p. m. ferrous iron. For all practical purposes it can be concluded that iron compounds offer no interference in the ortho-tolidin test.

Effect of Nitrites and Nitrates

Nitrates have never been found to interfere with the test.

Buswell and Boruff studied the effect of nitrites and concluded that when present in amounts less than 2 p. p. m. there is no interference. Quantities greater than this produce a *slowly* developing brownish color.

Experience at Pomona, California, with an under-aerated effluent from an activated sludge sewage plant indicated that heavy concentrations of nitrites in such effluents produce a slowly developing brownish yellow color which after 20 minutes is appreciable. Increased dosages gradually reduced the brown tints and finally the true yellow of residual chlorine appeared.

Morgan[16] reports that chlorination of the softened filtered water at Miami, Florida, results in oxidation of ammonia nitrogen to nitrite. The supply contains an extraordinary content of albuminoid and free ammonia. The paper does not contain figures for nitrite content, but the albuminoid and free ammonia content of the raw water is less than sufficient to produce 1 p. p. m. nitrite nitrogen whereas as pointed out less than 2 p. p. m. apparently does not interfere with the ortho-tolidin test.

Effect of pH Value

The hydrogen-ion concentration of the sample after addition of the ortho-tolidin is a matter of some importance.

Forsberg[14] noticed variable colors produced in the presence of residual chlorine when the final pH of the sample is not low enough. At pH 6.2 the color produced is a decided blue which changes to the true yellow upon further addition of reagent or dilute acid. At pH 4.8 the color is green, and below pH 4.5 is always the true yellow desired. From the investigations of Buswell and Boruff it would appear that the pH value after

adding the reagent may cover a range between pH 4.5 and some value which is probably as low as pH 1.0 for satisfactory results.

The writer early experienced difficulty with highly buffered solutions such as sewage tank effluents. It was soon found that the ratio of 1 cc. of reagent to 100 cc. of sample was inadequate when the standard 10% acid solution was employed. Not less than 1 cc. to 25 cc. of sample could be relied upon to produce maximum color values. Thus the desirability of more acidic solutions of ortho-tolidin was apparent, more particularly for sewage testing than for water. Tiedeman found that with less acid the color development was retarded considerably and results were lower than with solutions containing the same amount of ortho-tolidin but more acid. Although the increased acidity of the medium brings about more rapid development of maximum color, it likewise increases the rapidity with which the color fades in the presence of colloidal or soluble organic matter such as exists in settled sewage. It has been observed by the writer and E. Hurwitz at the Des Plaines Treatment Works in Chicago that the maximum residual chlorine values were secured in the activated sludge effluent when less than 1 cc. of 20% acid reagent was added to 25 cc. of sample. It is therefore apparent that in at least some instances the reagent should be added a little at a time until no additional color develops upon subsequent additions wherever knowledge of the optimum ratio of reagent to sample for some particular effluent or industrial waste is essential before proceeding with the test.

Effect of Temperature

The rate of color development after adding ortho-tolidin reagent is retarded to some extent by temperatures below 15° C. and the results are apt to be low even after a 5 minute contact following the addition of the reagent. Buswell and Boruff find that temperatures above 35° C. produce maximum colors within a few seconds but the intensity indicates a higher residual than is actually present. This is exactly the reverse condition observed when the starch-iodide test is applied. It has been shown that the starch-iodide test will be in error except within the range 20–30° C. (68–86° F.) and the ortho-tolidin test is most dependable within the range 15–35° C. (59–95° F.).

Time of Reaction

Considerable difference of opinion is expressed in the literature concerning the time required for reaction between ortho-tolidin and the sample before comparison with standards.

It is apparent that much of the difference of opinion has been caused by the temperature difference of the samples, or buffering effects previously mentioned. On the other hand, as will be shown later, the nature

of the materials present in the samples has a considerable bearing on the time of reaction necessary to secure maximum color development.

Ellms and Hauser[8] found 3 minutes' reaction period all that was necessary for water, although their data indicated that at temperatures above 15° C. the maximum color was secured after 15 seconds. Also, it is stated that the stronger the residual the more quickly is the maximum color developed and shaking hastens the reaction. It has been the experience of the writer that the reaction period in the case of waters at a temperature above 20° C. need not exceed one minute when the residual chlorine is less than 1 p. p. m.

The rate of color production varies considerably when chlorine, hypochlorite, chloramine and a chlorine complex "Halozone" (sulfon-dichlor-amino-benzoic acid) are dissolved in distilled water and the residual chlorine test applied. In the case of the chlorine or hypochlorite the color develops to a maximum very quickly, whereas the chloramine and "Halozone" require 10 to 20 minutes at ordinary temperature.

Bakke[17] at Dallas, Tex., observed the same effects which have been attributed to organic chloro-compounds formed in the pH zone above 8.4. The medicated tastes and the lag in maximum color production were both eliminated by reduction of the pH value of the softened water previous to chlorination.

With sewages the contact time needed to secure maximum color value with ortho-tolidin is somewhat variable. An increase in acidity secured by addition of hydrochloric acid after adding the ortho-tolidin reagent markedly reduces the contact time required. Increasing the quantity of ortho-tolidin reagent produces the same result. Addition of acid prior to the ortho-tolidin addition results in loss of residual chlorine because of the increased absorption by organic matter when the pH value is lowered. The same difficulty will be met if the pH is raised above 8.4 with alkali.

In general, then, it may be said that the period of contact required for maximum color development in connection with highly buffered waters, sewages or trade wastes will depend to a considerable extent on the pH value of the sample after addition of the reagent. To conserve reagent the ortho-tolidin solution should contain 18% to 20% C. P. hydrochloric acid by volume. In buffered solutions such as sewage, 0.5 cc. to each 15 to 20 cc. of sample is usually sufficient.

Frequently 1 minute of contact is sufficient. For greatest accuracy the maximum reading should be recorded by observations covering the period between 1 and 5 minutes of contact.

Indication of effective chlorination is had when the color is the true yellow reaching a maximum between 1 and 5 minutes of contact and holding the same intensity for the following 15 minutes.

Compensating for Color, Turbidity, Manganese and Other Interfering Substances

When interfering substances are present in water or sewage they may be compensated for in the ortho-tolidin test by the following method. A sample is collected at a point just ahead of that point at which chlorine is applied and another is collected which is representative of the chlorinated material. Ortho-tolidin reagent is added to both samples in like amount. The unchlorinated samples, "blanks," are placed in the rear of the standards and a bottle or ampoule of water is placed behind the chlorinated sample. Comparison of standards and unknowns is made by viewing the pairs transversely. Thus, in every case, the combinations include all influencing factors plus residual chlorine color. These interferences are thereby compensated for and the true residual chlorine only is recorded. In cases where the interference is caused by coloring matter, turbidity or opalescence, the chlorinated samples to which no ortho-tolidin is added are employed as "blanks."

Permanent Residual Chlorine Standards

Permanent standards prepared from copper sulfate and potassium dichromate solutions according to the method of Ellms and Hauser[9] which appears in Standard Methods of the A. P. H. A. or according to the modification of Muer and Hale[10] are accurate only when used in standard Nessler tubes. Comparison of unknowns with such standards through depths of solution considerably less than the depth for which these empirical standards were prepared leads to error which is negligible up to 0.2 p. p. m. residual chlorine but increases as the residual increases.

In order that comparison of standards with the unknown in tubes, small bottles, ampoules, etc., viewed transversely with accurate results be assured, it is necessary to compound standards to suit the lesser depth of liquid.

Ortho-Tolidin Reagent

The preparation of a 1% solution of ortho-tolidin in dilute hydrochloric acid has given considerable trouble in that heating was apparently necessary and even then some undissolved ortho-tolidin usually remained. The method devised by Theriault[11] is so simple and effective as to justify quoting:

1. Place one gram of ortho-tolidin in a small mortar and add 5 cc. of 1:5 hydrochloric acid (previously prepared by adding 100 cc. of concentrated hydrochloric acid, sp. gr. 1.18–1.19 to 400 cc. distilled water).

2. Grind to a thin paste and add 150 to 200 cc. distilled water. The ortho-tolidin goes into solution immediately.

3. Transfer the solution to a 1000-cc. flask or graduate and make up to slightly less than 500 cc. with additional distilled water.

4. Add the remaining 1:5 acid (495 cc.) and complete the dilution to the 1000 mark with more distilled water.

Author's Note—For use in testing alkaline waters or sewage it is recommended that the acid content be increased to 200 cc.

Period of Contact of Chlorine and Water

When comparison is made between a chlorinated sample which has been allowed to stand for a ten-minute period before addition of ortho-tolidin and a chlorinated sample to which ortho-tolidin has been added immediately after the chlorination, both held for the same time after addition of ortho-tolidin, the sample to which the ortho-tolidin was added immediately will frequently show a higher residual. The chlorine apparently reacts with the ortho-tolidin and the chlorine absorption by the organic matter in solution is thereafter not so marked as is the case when the absorption proceeds in the absence of ortho-tolidin. In waters of low organic content little difference is noted, but best practice calls for a ten-minute period of contact before addition of ortho-tolidin. This contact period may already have elapsed between chlorination and sampling, in actual plant practice, in which case no holding time is required.

Since the introduction of the residual chlorine control procedure many valuable contributions have come from workers in this field, and it is hoped that this work will continue to be carried forward toward ever increasing perfection.

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Experiments on the Purification of Beet Sugar Wastes by Stream-Flow Aeration

BY MAX LEVINE[1] AND G. H. NELSON[2]

The purification of wastes originating from the manufacture of beet sugar has become a serious problem in the State of Iowa. Unless suitable and economical means are devised for treatment of this industrial waste, the very existence of the industry in this state is threatened. The problem is further aggravated by the seasonal character of the industry. Beet sugar is manufactured for a period of 70 to 100 days in the fall of the year, (generally from about October 10 to January 1) when the streams receiving the wastes are likely to be covered with a sheet of ice, which effectually prevents reaeration, and consequently greatly retards self-purification.

Volume and Character of Wastes

The Mason City, Iowa, plant of the American Beet Sugar Company is situated on Lime Creek, a small stream of very variable flow frequently discharging but 20 to 30 million gallons of water per day. During the operating season, there is produced about 4,500,000 gallons of waste water per day.

The wastes may be classified as follows:

(*a*)	Steffens waste, about	200,000 gallons per day
(*b*)	Lime waste, about	200,000 gallons per day
(*c*)	Wheel water, about	3,500,000 gallons per day
(*d*)	Pulp water, about	700,000 gallons per day

The Steffens and lime wastes are, at present, not contributing to the problem of stream pollution. The wheel waste consists of the water used for fluming and washing the beets, and contains considerable silt and beet tailings, but is relatively low in oxygen-demanding materials until the latter part of the operating season. The pulp water consists of washings from the diffusion cells and pulp presses, is high in oxygen-consuming and demanding substances, and contains considerable finely suspended pulp particles.

This paper is restricted to a consideration of the treatment of pulp water by aeration. This waste had an average oxygen demand of 1120 p. p. m. and oxygen consumed of 1287 p. p. m. The total solids content was 2557 p. p. m., of which 545 parts (or 21.3 per cent) was suspended, and 2012 p. p. m. dissolved. Of the total solids 2155 p. p. m. or 84.5 per cent was volatile. The suspended solids were also primarily organic in nature, 414 p. p. m. or 79.5 per cent being volatile. The waste was comparatively

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low in nitrogen content, with 17.9 p. p. m. nitrogen as ammonia, and 38.1 p. p. m. as organic nitrogen. The ratio of oxygen consumed to organic nitrogen was approximately 34 to 1, indicating the highly carbonaceous character of the waste. In previous experiments with milk wastes (Levine & Soppeland, 1926), which showed a ratio of oxygen consumed to organic nitrogen of 10 to 1, it was found that anaerobic methods were not suitable because of the development of inhibiting acidities.[3] It was therefore evident that some direct aerobic method would be more desirable for successful purification of pulp water.

Aerobic Processes of Treatment

In 1920 Pearse and Greeley[4] reported results of experiments with trickling and sand filters. With a waste of 1000 p. p. m. biochemical oxygen demand, applied at a rate of 168,000 gal. per acre per day to trickling filters, an effluent of 285 p. p. m., B. O. D. was obtained. Sand filters dosed at 92,000 gal. per acre per day, gave an effluent of 282 p. p. m. oxygen demand. These results indicate the refractory nature of this waste to treatment, and the extreme expense involved if more efficient methods are not discovered or developed.

Numerous experiments were conducted with trickling filters which gave very encouraging results and will be reported on completion of the investigations. The possibilities in the use of the activated sludge process appeared promising, but the large amount of air required would be very expensive. It was thought that pumping the liquid over an aerating surface, if feasible, would be much more economical. Such a device, designated as "stream-flow purification" was found by Jenks and Levine[5] to be highly efficient in experiments with packing-house and milk wastes. The laboratory plant employed in these experiments was set up for the treatment of pulp water.

Stream-Flow Aeration

The experimental unit consisted of a cylindrical tank of a size sufficient to treat 15 gallons of waste and was operated on the fill-and-draw basis (Fig. 1). The liquid was pumped from the bottom of the tank to a trough 6 ft. long and 6 in. wide, from which it flowed back into the tank. The trough was supplied with cleats, which caused the formation of ripples

[3] "Proteolysis by Bacteria from Creamery Wastes," *Iowa Engr. Expt. Sta. Bulletin*, **1926**, 82.

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[4] Langdon Pearse and Samuel A. Greeley, "Treatment of Beet Sugar Plant Sewage," *Amer. Jour. Pub. Health*, **10**, 312–323, 1920.

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as the waste flowed down and became aerated, in what appeared like a miniature turbulent stream, about $\frac{1}{2}$ to $\frac{3}{4}$ inches deep. The pump employed was a small gear pump, which delivered about 15 gallons a minute.

The waste treated consisted of the unsettled pulp water, since preliminary observations indicated that as good results were obtained with the crude as with the settled waste.

The method of operation was briefly as follows: The tank was filled, the pump started, and after six hours a sample was withdrawn for examination. Aeration was continued until the next day (22 hours) when another sample was withdrawn for analysis. The pump was now stopped,

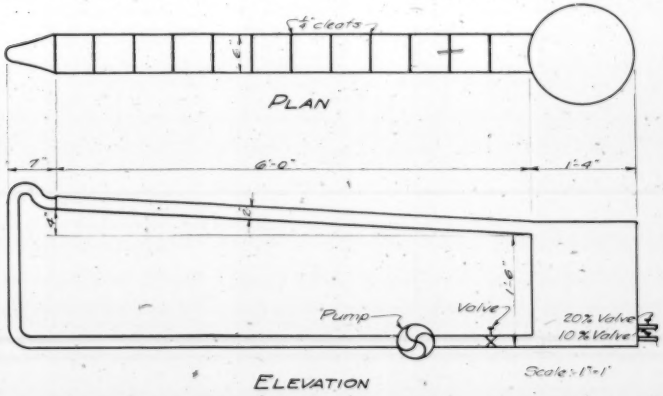

Fig. 1. Diagrammatic Sketch of Experimental Stream Flow Aeration Unit. (After Jenks & Levine)

the accumulated sludge allowed to settle for one hour, after which the upper 80 per cent of the tank contents were discarded, a fresh batch of pulp water added, and aeration and sampling carried out as before.

The samples taken after 6 and 22 hours' aeration were allowed to settle for one hour in quart Mason jars, the depth of sludge after 30 and 60 minutes recorded, and the supernatant liquid examined for reaction (pH), oxygen consumed, and oxygen demand. Composite samples for complete chemical analysis were obtained by taking 100-cc. portions of the raw wastes and of the supernatant liquid of these daily 6- and 22-hour aerated samples. In the last series of observations a 10-hour sample was also taken.

Result of Treatment

The results of the chemical analyses of three series of composites of daily samples are shown in Table I.

TABLE I

ANALYSES OF COMPOSITE SAMPLES SHOWING PURIFICATION EFFECTED BY STREAM-FLOW AERATION OF PULP WATER

(Expressed in Parts per Million)

	Oct. 16–Nov. 4, '27			Nov. 9–Dec. 1, '27			Dec. 2–11, '27		
		Effluents			Effluents			Effluents	
	Raw	6 hr.	22 hr.	Raw	6 hr.	22 hr.	Raw	6 hr.	22 hr.
Solids									
Total	2260	1208	804	2532	1428	900	2880	1692	1284
Susp.	516	180	112	532	116	32	588	80	204
Volatile Solids									
Total	1868	828	380	2140	1056	540	2416	1272	856
Susp.	396	118	52	392	64	32	464	8	148
O_2 Cons.									
Total	1100	394	143	1200	450	196	1470	795	364
Dis.	970	362	133	1100	438	186	1360	790	354
Susp.	130	32	10	190	12	10	110	5	10
Nitrogen									
NH_3	20	2.3	5	20	2.0	0.1	13.6	3.5	1.0
Org.	33	24.3	14.0	36	16.0	10.4	45.4	15.5	15.0
Nitrite	0.22	0.01	0.02	0.05	0.01	0.02	0.12	0.03	0.02
Nitrate	0.08	0.64	0.43	0.15	0.04	0.03	0.18	0.12	0.28
Temp., ° C.	48.0	37.6	34.3	45.3	33.2	30.0	45.5	31.6	28.9
pH	6.1	7.2	7.9	6.5	6.9	7.4	6.6	7.3	7.5
				Per Cent Reduction					
Solids									
Total		46.5	64.4		44.3	64.4		41.2	55.4
Susp.		65.1	78.2		78.2	94.0		86.4	65.3
Volatile Solids									
Total		55.6	79.6		50.6	74.8		47.2	64.5
Susp.		70.2	86.9		83.7	91.6		98.3	68.0
O_2 Cons.									
Total		64.2	87.0		65.1	84.8		46.0	75.2
Dis.		62.6	86.3		60.2	83.1		41.9	74.0
Susp.		75.4	92.3		93.7	94.7		95.5	90.9
Nitrogen									
NH_3		88.8	75.0		90.0	99.5		74.4	92.6
Org.		26.3	57.5		55.5	71.1		65.8	66.9

Reductions of 41.2 to 46.5 per cent of total solids, and 65.1 to 86.4 per cent of suspended solids were obtained by 6 hours of aeration, while aeration for 22 hours effected reductions of 55.4 to 64.4 per cent total solids and 65.3 to 94 per cent of suspended solids.

Volatile solids were reduced 47.2 to 55.6 per cent by 6 hours' aeration which included 70.2 to 98.3 per cent of the suspended volatile solids. Continuing aeration for 22 hours showed reductions of 64.5 to 79.6 per cent total volatile solids and 68 to 91.6 per cent suspended volatile solids.

Oxygen-consuming constituents were reduced 46 to 65.1 per cent by six hours, and 75.2 to 87 per cent by 22 hours aeration.

There was no evidence of any appreciable nitrification, even after 22

TABLE II

SHOWING EFFECT OF STREAM-FLOW AERATION ON OXYGEN DEMAND OF BEET SUGAR WASTE (PULP WATER)

Sample Date, 1927	Raw	Effluents 6 Hours	10 Hours	22 Hours
	B. O. D. in p. p. m. (5 days, 20° C.)			
Oct. 19	1120	...		108
21	...	...		70
24	900	295		125
25	880	295		125
26	...	260		80
29	940	390		90
31	...	300		445
Nov. 3	1275	375		42
5	...	210		28
8	1375	275		51
10*	...	620*		78
13	1150	480		112
15	...	400		100
18	1050	680		130
20	...	250		76
23	1050	600		135
25	...	520		350
28	1150	338		180
30	...	230		120
Dec. 3	1050	288	230	170
5	...	240	180	48
9	1350	400	350	175
11	1300	288	160	165
Average	1120	368	230	117
Reduction, per cent		67.2	79.5	89.6

* High results November 10 to 25 due to loss of capacity of small gear pump. This was remedied by speeding up pump.

hours aeration, but ammonia and organic nitrogen were markedly eliminated. Thus, there were decreases of 74.4 to 90 per cent in ammonia, and 26.3 to 65.8 per cent organic nitrogen after 6 hours aeration. Continuing aeration for 22 hours showed reductions of 75 to 99.5 per cent ammonia and 57.5 to 71.1 per cent organic nitrogen.

The raw wastes were acid in reaction (pH 6.1 to 6.6). The six-hour effluents were neutral or slightly alkaline (pH 6.9 to 7.3), and the 22-hour effluents more alkaline with pH 7.4 to 7.9.

The oxygen demand results are shown in Table II and summarized graphically in Chart 1. An average 5-day demand of 1120 p. p. m. was reduced to 368 p. p. m., 230 p. p. m. and 117 p. p. m., by aeration for 6, 10 and 22 hours, respectively, corresponding to reductions of 67.2, 79.5 and 89.6 per cent. It appears from Chart 1 that aeration for periods

longer than 10 or 12 hours would be economically very wasteful, and that a reduction of about 50 per cent in B. O. D. may be anticipated by 3 hours aeration.

Stream-flow aeration of pulp water gave very satisfactory and promising results, but owing to the short time available for experimental observation during a single manufacturing season, opportunity for working out engineering details for a full size plant must of necessity be deferred to later studies.

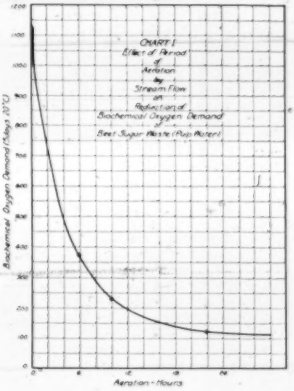
CHART I
Effect of Period of Aeration by Stream Flow on Reduction of Biochemical Oxygen Demand of Beet Sugar Waste (Pulp Water)
Biochemical Oxygen Demand (Days 20°C)
Aeration - Hours

Acknowledgment

We desire to express our appreciation and indebtedness to Mr. W. H. Baird, Superintendent of the Mason City plant of the American Beet Sugar Company, for his keen interest in this problem of waste disposal, which made this study possible, to Professor Harry N. Jenks for helpful suggestions, and to Mr. G. W. Burke for assistance in the chemical analyses.

[*Editor's Note.*—The first article by Messrs. Jenks and Levine on the stream-flow process was reprinted from *Engineering News-Record* (Ref. 5) in *The Surveyor* for Aug. 17, 1928. It is followed by a review written by Mr. H. C. H. Shenton, who has frequently discussed the activated sludge process in the columns of *The Surveyor*.

Mr. Shenton states that "the use of pumps to produce agitation, and flow through the tanks to produce aeration is nothing new, but the method brought forward by the authors appears to differ from all other methods by the fact that the sewage is made to run along channels of relatively short length and of very shallow depth." . . . "it is difficult to understand why this method should prove to be more economical than those already adopted." Mr. Shenton questions the desirability of adjusting the intensity of aeration (or circulation) to the rate of oxygen demand of the sewage because of the much greater and more constant oxygen demand of the sludge. He discusses the question of presedimentation and the multi-stage process, referring to an actual installation of a three-stage process in Finland. He regrets that "the stream-flow method is clearly put forward as a rival to the diffused-air method," and considers investigations of the scientific principles involved to be more important at the present time than economic development of the process.]

Sewage Works Operation

Carbohydrate Wastes Stimulate Growth of Undesirable Filamentous Organisms in Activated Sludge

By E. H. Morgan and A. J. Beck[1]

The Des Plaines River Treatment Works of the Sanitary District of Chicago has been in operation since August, 1922. The sewage contains practically no industrial waste. No serious difficulties in operation of the activated sludge process were encountered until the latter part of June, 1927, when the sludge began to bulk and flow over the effluent weirs, the oxygen demand of the sewage increased markedly, and nitrates almost disappeared in the effluent.

The sludge changed visibly in appearance as well as in its properties. Instead of well-formed, spongy flocs it became slimy and gelatinous and would not settle. It contained numerous small pellets surrounded by a slimy coating, which would settle fairly rapidly but the bulk of the sludge was fluffy and like egg albumin in appearance.

A microscopic examination showed that the flocs were almost entirely masses of intertwined filaments. The small pellets mentioned above appeared to be more solidly agglomerated clumps of the organism and the sludge matter, entwined by continuous agitation in the aeration tanks. The filaments do not grow from these balls but are merely entangled throughout them.

A description of the organism, its identification as *Sphaerotilus*, and results of laboratory experiments on its growth in pure culture are given in the accompanying article by Ruchhoft and Watkins.

Results of Operation

Unusual frequency of filamentous growths in the aeration tanks was first noted during the summer of 1926, but they decreased during the winter of 1926–27 so that no consistent deterioration of the quality of effluent appeared until June, 1927. In Fig. 1 are shown monthly averages of operating results and partial analyses for the years 1926 and 1927.

It will be noted that there was a great increase in the 5-day B. O. D. of the raw sewage in June, 1927, but without a corresponding increase in suspended solids. In July, 1927, there was an enormous increase in the oxygen demand to 464 p. p. m. and a decided increase in suspended solids.

[1] *Principal Asst. Chemists, Des Plaines River Treatment Works, The Sanitary District of Chicago.*

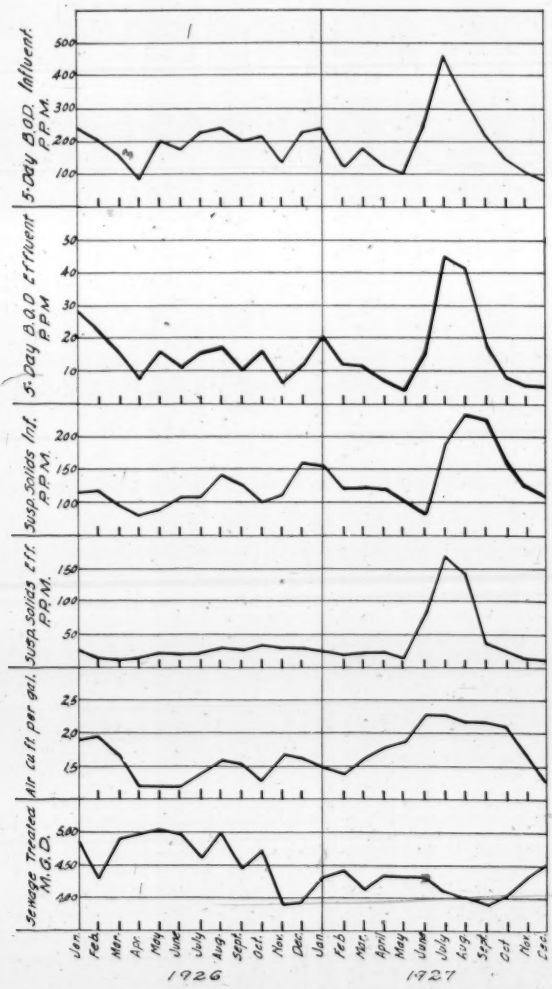

FIG. 1.—Average Monthly Analyses and Operating Results, Des Plaines Treatment Works.

The source of the difficulty was determined in July. For the first half of August the sewage containing the troublesome wastes was diverted from the intercepting sewer and directly to the river. Later, this sewage was again put through the plant to demonstrate that it was the cause of the trouble, but finally on Oct. 4, 1927, it was diverted permanently. The oxygen demand and suspended solids of the raw sewage returned to normal values in November and December.

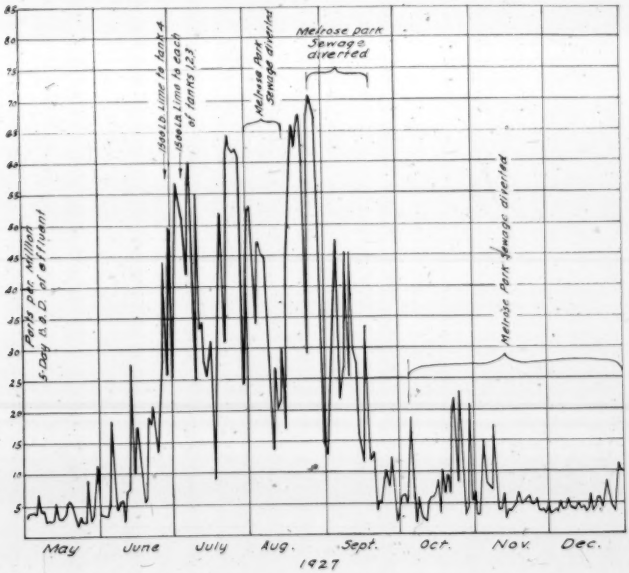

FIG. 2.—Biochemical Oxygen Demand of Activated Sludge Effluent, Des Plaines Treatment Works.

The quality of the effluent from June 20 to September 20 was quite unsatisfactory, except at times when the troublesome sewage was diverted. A daily record of the oxygen demand of the effluent from May through December, 1927, is shown in Fig. 2.

The amount of air was increased considerably from June through October, as shown in Fig. 1, in order to improve conditions. Laboratory experiments indicated that prolonged aeration would improve the condition of the sludge. It was usually possible to accomplish the same results in the

plant by shutting off the sewage flow and aerating sludge and sewage for several days, but with continuous flow of sewage and even as much as 2.6 cu. ft. of air per gallon it was impossible to keep the sludge in good condition.

Chemicals Added

Laboratory experiments were conducted to determine whether it would be possible to add some cheap chemical to neutralize the effect of the waste.

Copper sulphate was applied to the mixture of sludge and sewage up to 30 p. p. m. with little effect on the growth of the organism, but when 100 p. p. m. was added both bacteria and organisms were killed.

Chlorine was added in large amounts. Fifty or 100 p. p. m. would kill the organisms and also practically all the bacteria. Smaller quantities of copper sulphate and chlorine had little effect.

Filter alum, alum plus sulphuric acid, salt(NaCl), sand, filter-cel, super-cel, pumice stone, iron oxide, zinc dust and ferrous sulphate were added with practically no improvement in condition of the sludge.

It had been noted that the pH of the sewage and sludge in the aeration tanks was quite low, averaging 5.6 to 6.2, with 5.2 as an occasional mimimum. The addition of lime was logical and this was done at the plant early in the summer. On June 24, 1927, dry hydrated lime (1500 lb.) was added to the aerated sewage and sludge in Tank 4 just before it entered the settling tank. The flow of sewage to Tank 4 for this day was 0.563 m. g. d. and of return sludge 0.394 m. g. d., consequently 188 p. p. m. was added. The influent sewage was then shut off and the treated liquor aerated for several days. This large amount of lime coagulated the floc which regained its brown color and appearance, but when sewage was again admitted to the tank, it soon returned to the slimy condition. Later on July 5, 1927, an equal amount of lime was added to each of Tanks 1, 2 and 3 with some improvement for the following week, followed by a recurrence of bad effluents. It was apparent that the difficulty could be controlled fairly well by the addition of large amounts of lime and a dry-feed machine was installed for this purpose. Later in July, however, the source of the waste was discovered and the sewage containing it was diverted to the river.

Source of Wastes

The acid pH of the aerated sewage and occasional low values in the incoming sewage suggested the presence of acid wastes but mineral acids were known to be absent. The increased B. O. D. without corresponding increase in nitrogen indicated carbonaceous wastes. Dairy wastes had been reported by Hall in Montana (see reference in following paper) as the cause of similar growths in sewers. No dairies of consequence were found on the sewer system tributary to the treatment works.

A systematic analytical survey of the sewer system was then made.

There are seven villages in the sewer system. Samples were collected from manholes throughout the system many times and tested for pH and presence of filamentous organisms.

It was found that sewage in the village of Melrose Park was acid, and a value as low as 4.0 was found in one sample from a 10-inch sewer in this village. Samples from this sewer had an odor of fermented grain or sugar. The following analysis indicates that an enormous amount of dextrose was present.

SAMPLE FROM SEWER IN MELROSE PARK

August 29, 1927

Determination	P. p. m.
Total solids	12,000
Volatile	11,320
Fixed	680
Dissolved solids	11,088
Volatile	10,492
Fixed	596
Suspended solids	912
Volatile	828
Fixed	84
Organic nitrogen	103
Dextrose	10,400
pH	5.0

This sample and a number of others demonstrated that residues from illicit fermentation and distillation were being dumped into the sewers in enormous amounts. Corn sugar (crystallized dextrose) is a favorite substance for this industry. We have made a rough calculation of the amount of sugar received at the treatment works from the increase in 5-day B. O. D. in July, 1927, as compared with the average B. O. D. of 194 p. p. m. and flow of 7,360,000 gallons per day in 1926, equivalent to 11,890 lb. B. O. D. per day or a population of 71,600, using a factor of 0.166 lb. per capita. This is known to be approximately the human population plus a small amount of industrial waste.

In July, 1927, the 5-day B. O. D. was 464 p. p. m. and the flow 5,480,000 gallons, requiring daily 21,190 lb. oxygen. The increase is 21,190 − 11,890 = 9300 lb. 5-day B. O. D. or 13,670 lb. for complete demand (first stage). Assuming that dextrose is oxidized to water and carbon dioxide as follows:

$$C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O$$

the equivalent of 13,670 lb. oxygen would be 12,800 lb. dextrose per day discharged into the sewer. This estimate is not unreasonable in view of subsequent developments. These may best be expressed by quoting from *The Chicago Tribune* for June 2, 1928:

Ninety-nine residents of the village of Melrose Park were named yesterday in an indictment charging a conspiracy to violate the prohibition law by the operation of 119 stills in homes in Melrose Park.

The indictment was returned by the federal grand jury and was based on the testimony of more than three hundred persons who appeared to testify.

. . . . . The syndicate is alleged to have operated 119 stills in the village with an estimated output of 1,000,000 gallons of alcohol yearly.

The Assistant United States District Attorney in charge of the case stated that the group used 11,000,000 pounds of sugar annually in the production of alcohol. He estimated that the stills netted an income of $5,000,000 yearly.

The indictment sets up that the conspiracy was launched on April 1, 1927.

Conclusions

While this experience is probably unique in the operation of sewage treatment works it may have some general bearing on the problem of bulking of sludge and interference with the normal operation of the activated sludge process. Walter Scott, Chemist of the Bury (England) activated sludge plant, has made experiments[2] which seem to indicate that excessive amounts of carbohydrates in sewage cause rapid increase in the volume and consequently in the moisture content of activated sludge. He added milk wastes, starch, brewer's yeast and glucose to good activated sludge from the Bury treatment works. Yeast alone caused some increase in volume, but yeast plus 2000 p. p. m. glucose caused very pronounced bulking, the volume increasing from 10 to 79 per cent in eight days. In further tests the volume increased from 30 to 71 per cent in one day.

H. W. Clark long ago showed that excessive amounts of carbohydrates prevent nitrification. There were practically no nitrates in the Des Plaines effluent when the waste was present, but from 8 to 10 p. p. m. after it was removed.

Bulking of sludge, loss of nitrification and other difficulties that have been encountered in operation of activated sludge plants may, in many cases, be caused by wastes similar to those described in this paper, although most likely in lesser amounts.

[2] Walter Scott, "Bulking of Activated Sludge," *The Surveyor*, **73**, 345–7 (March 23, 1928).

Bacteriological Isolation and Study of the Filamentous Organisms in the Activated Sludge of the Des Plaines River Sewage Treatment Works

By C. C. Ruchhoft[1] and J. H. Watkins[2]

Filamentous organisms similar to those present in the activated sludge of the Des Plaines plant of the Sanitary District of Chicago in the summer of 1927 have been reported as troublesome in sewage by sanitary engineers both in this country and abroad. These reports usually refer to the organism as *Sphaerotilus* and suggest various methods for its destruction and control, but describe neither the characteristics nor the microscopic appearance of the organism. Goudey[1,*] mentions growths of *Beggiatoa* and *Sphaerotilus* in outfall sewers, but it is doubtful whether the latter played a material part in the conditions described. Hall[2] experienced difficulties with growths of *Sphaerotilus natans* and *Leptomitus* in a sewer receiving creamery wastes and claimed that an application of about 2 p. p. m. of copper sulphate eliminated the growths. At Wakefield, England, Hoyle[3] reports difficulties with *Sphaerotilus* growths in an activated sludge plant similar to those encountered by Morgan and Beck. He stated that he was able to conquer the difficulties by adding humus to the aeration tanks, but discussion of his remarks cast some doubt upon the permanence of his remedy.

Description of Organism

A microscopic examination of the sludge from the tanks shows a long filamentous organism running through and around the amorphous material (Fig. 1). The organism is a straight filament, having no branches or joints. No differentiation of any part is noted, the whole consisting of a continuous imperceptible sheath, enclosing homogenous cells placed closely end to end, and of a length but little greater than the diameter (Fig. 2). Under the high power the cells appear as thin discs, which occasionally have separated, revealing the thin colorless sheath. A faint green color is observed under the oil immersion which cannot be seen under lower power. No granules or deposits are ever observed. The diameter of the filament is 2.0–3.0 micra, the length of the individual cells, 2.0–4.0 micra. The filaments are seldom less than 1000 micra long and frequently are 5000 to 6000 micra in length. A stained slide of the filament reveals little more than an examination of the unstained material (Fig. 5). The cells are

[1] *Bacteriologist, The Sanitary District of Chicago.*
[2] *Assistant Bacteriologist, The Sanitary District of Chicago.*
* Numbers in text refer to bibliography at end of article.

gram negative, and appear merely as cells placed end to end, the sheath being infrequently apparent.

Isolation of Organism

Although the organism was shown microscopically to be present in vast numbers in the tanks and sludge, its isolation was attended by several difficulties. A medium had to be found upon which it would grow, and some means used to suppress or eliminate the ordinary forms of bacteria which are constantly present in large numbers in activated sludge. Raw sewage sterilized in bottles, in depths of about one-half inch, was found to support growth of the organism when a considerable inoculum was used. This inoculum simultaneously introduced contaminating bacteria which grew as well or better than the organism and prevented the successful use of dilution methods. Isolation was finally accomplished in the following manner: Several cubic centimeters of the tank liquid were placed in a sterile centrifuge tube, and after stoppering with a sterile cork, vigorously shaken for several minutes. This broke up the filaments and to some extent washed the bacteria from them. The tube was then centrifuged at a speed and for a length of time merely sufficient to throw down the filaments and larger debris. The supernatant liquid was pipetted off, sterile distilled water added, the tube again shaken and centrifuged. This was repeated several times, and after the final centrifuging the tube was set aside for five or ten minutes until the sludge had settled, leaving large numbers of filaments in the supernatant liquid. The liquid was then streaked on plates of hardened dextrose-phosphate agar of the following composition: dextrose, 10 grams; peptone, 5 grams; K_2HPO_4, 1 gram; agar, 10 grams and distilled water, 1000 cc. The pH of the medium was adjusted to 7.0–7.2 with NaOH before sterilization.

The plates were inverted, incubated at 20° C., and examined unopened after one or two days. Filamentous colonies free from contamination were located under the low power of the microscope and subsequent growth was observed for 4 or 5 days when colonies visible to the naked eye were picked into sterile sewage or broth of composition similar to that of the agar used for isolation. Abundant growth of the organism in both sewage and broth was found after 24 hours incubation at 20° C. The culture was tested for purity by being inoculated onto plain agar slants, which showed no growth, and by stained smears, which seldom revealed the presence of the smaller bacteria.

Description of Cultures

The colonies, macroscopically indistinguishable from those of many other bacterial forms, are slow growing, punctiform, with a rough surface, raised or convex elevation, and curled edge. As seen under the low power

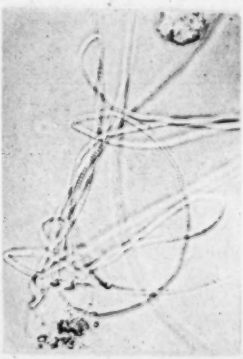

Figure 2

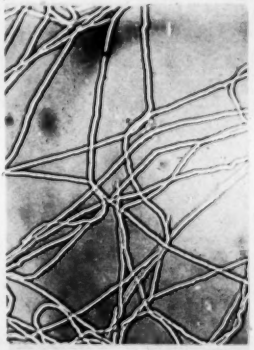

Figure 4

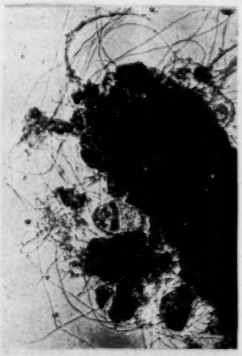

Figure 1

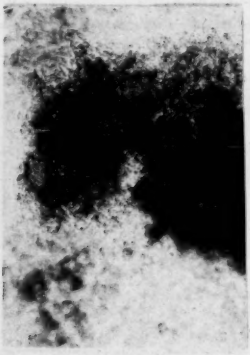

Figure 3

of the microscope (Fig. 3), the filamentous structure is plainly evident, the filaments being roughly curled, and running in irregular directions.

Growth in dextrose-phosphate broth is quite rapid, a fluffy white filamentous precipitate appearing in the bottom of the tube after 24 hours incubation at 25° C. The upper part of the broth is absolutely clear. Upon shaking, the deposit rises, breaks up, and is distributed throughout the liquid. After a few hours settling, however, the growth reassumes its original appearance.

Microscopically, the filaments from the cultures are somewhat different from those in sludge (Figs. 4 and 6). Their diameter is slightly less, being 1.5–2.0 micra and the cells are longer, averaging 3.0–5.0 micra. The cultured cells are not as close together within the sheath, oftentimes only slightly touching. The average length of the filaments is not changed, but instead of being slightly curved the filaments are irregularly bent, suggesting a labored growth, due perhaps to the incomplete adequacy of the dextrose-phosphate broth as a culture medium. Upon re-inoculation into sterilized sewage, the filaments almost completely reassume their original appearance.

The presence of dextrose in the medium appears requisite to growth of the organism, although a slight deposit is obtained in broth containing no dextrose when inoculated from a young, vigorously growing culture. The presence of beef extract in the medium prohibits growth. Chodat's medium, which utilizes $NaNO_3$ as a source of nitrogen and atmospheric CO_2 as a source of carbon, also failed to support growth. The organism grows in lactose-phosphate broth, a slight acidity being produced in this as in dextrose-phosphate broth. The organism is comparatively short-lived in artificial media. Even in dextrose-phosphate broth and sterilized sewage, in which it grows best, the filaments died in 3 to 4 weeks or less, regardless of early transplantations.

Optimum growth is obtained in broth at 20 to 25° C., with a pH between 7.0 and 8.0. No growth ever appeared with a pH less than 6.0 or greater than 8.8. Growth is not only suppressed, but the organism is killed

PHOTOMICROGRAPHS OF THE FILAMENTOUS ORGANISM, SPHAEROTILUS

Fig. No.	Subject	Treatment	Magnification
1	Sludge particle surrounded by the filamentous organism	Natural	120 ×
2	Filamentous organism in sludge	Natural	560 ×
3	Colony on dextrose-phosphate agar	Natural	120 ×
4	Organism from broth culture	Natural	560 ×
5	Organism from sludge	Stained with aqueous fuchsin	1180 ×
6	Organism from culture	Stained with aqueous fuchsin	1180 ×

when subjected to a pH less than 6.3, as shown by the fact that broth tubes of pH 7.4 inoculated from tubes with a pH less than 6.3 showed no development of the organism.

The filaments grew as well in the dark incubators as in the light. Since the organism appeared to have a slight green color under the oil immersion an attempt was made to extract chlorophyll from massive cultures with ether, petroleum ether, and ether-alcohol, but without success. These

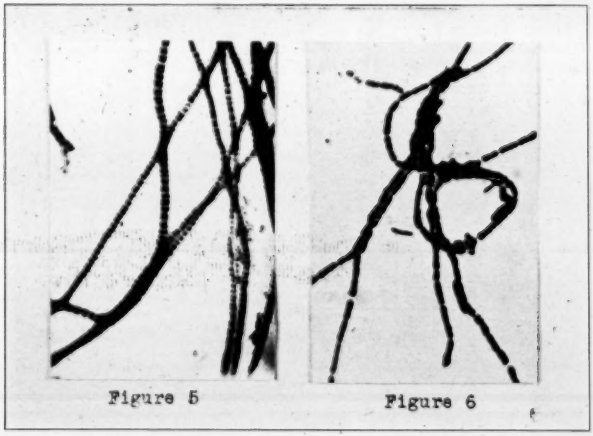

Figure 5 Figure 6

facts, together with that of the failure of the organism to utilize atmospheric CO_2, lead to the conclusion that the organism contains no chlorophyll.

The addition of ferrous ammonium sulphate to sterile sewage failed to increase growth of the filaments, nor was any change apparent in their character or appearance. None of the media suggested by Ellis[4] for the isolation and growth of the various iron bacteria could support growth of the filaments.

Identification

A sample of the tank sludge, preserved with formaldehyde, was sent to Mr. W. C. Purdy, of the U. S. Public Health Service, for examination and identification. Mr. Purdy replied, saying that he believed it to be a variety of *Sphaerotilus* but was not sure that it was *Sp. natans*. Others who have encountered *Sphaerotilus* in water have also identified this organism as such, and we have not seen fit to suggest another designation at this time.

Sphaerotilus has long been recognized as an inhabitant of grossly polluted waters. Senft[5] gives its chief habitat as sewage, especially wastes from breweries and sugar factories, and groups it among organisms, the presence of which in water is strongly indicative of sewage pollution. Ohlmüller and Spitta[6] designate it as one of the most characteristic and common sewage organisms. *Sphaerotilus* has been noted in abundance by Forbes and Richardson[7] in both the Des Plaines and Illinois rivers. It appears essential, however, to emphasize the chief points of difference between the organism studied by us and the more commonly described species of *Sphaerotilus*.

Bergey[8] describes *Sphaerotilus* thus: "Attached, colorless threads showing false branching, making a pseudodichotomy. Filaments consist of rod-shaped or oval cells, surrounded by a thin, firm sheath. Multiplication occurs both by non-motile and motile conidia, the latter with a clump of flagella near one end." In no instance was branching, true or false, ever observed in sewage, sludge, or agar and broth cultures, by the organism studied by us, in spite of the fact that special attention was paid to this. We were never able to observe attachment of the filaments to particles of sludge or to other filaments. Cultures grown in dextrose-phosphate broth and in sewage which contained a layer of sand and soil in the bottom of the tubes were examined, but although the organism grew over and around the particles, they were not attached and could be readily dislodged by shaking. The presence of motile conidia, though sought for, was never noted, particularly in the cultures.

Ellis[4] regards *Sphaerotilus* as a variant of *Cladothrix*, and as such, one of the iron bacteria. No evidence has been obtained of a relation between the presence and absence of iron compounds in the medium and this organism. Because of this and the fact that morphologically it resembles none of the common iron bacteria, it is believed that the organism is not a member of this group.

Experimental

Laboratory experiments showed that prolonged aeration of the sludge up to 96 or 120 hours helped the settling quality of the sludge and greatly reduced the number of filaments but did not eliminate them.

Morgan and Beck found lime very effective in treating the sludge. Our experiments confirmed this and showed that in doses of 500 p. p. m. or over most of the filamentous organisms are dissolved or disintegrated in a short time. Doses of from 100 to 500 p. p. m. are also decidedly helpful in reducing the filaments but doses under 100 have little, if any, effect in sludge.

Conclusions

A study was made of a filamentous organism, which over-ran the activated sludge tanks of the Des Plaines Treatment Plant of the Sanitary District of

Chicago. The organism was considered as belonging to the genus *Sphaerotilus*, but exhibits no branching, is never attached, and never shows the production of motile conidia.

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The Control of Foaming and Odors of Imhoff Tanks. Texas and California Experiences with Chlorine and Lime

I. Tests at Lufkin, Texas[1]

By Chester Cohen[2]

During the summer of 1926 the Engineering Division of the Texas State Department of Health was requested by the city authorities of Lufkin, Texas, to assist in correcting foaming conditions at the sewage works. The gas vent walls of the Imhoff tanks had already been raised with flash boards to an elevation two feet above the flow level. Daily hosing of the vents and frequent sludge withdrawals had proved inadequate and the foaming continued. The liquor in the foam and in the gas vents beneath had an alkalinity of pH 7 to 8. During the periods of serious foaming the gas evolved contained considerable hydrogen sulphide and brought complaints of odors by nearby residents.

Addition of lime to the vents and sludge digestion chambers produced slight improvement but only temporary relief.

On the assumption that foaming conditions were largely due to abnormal physico-chemical conditions of the material in the gas vents in combination with the quantity and quality of gas resulting from certain predominating

[1] *Presented at Tenth Annual Texas Water and Sewage Works School, January 24, 1928.*

[2] *District Sanitary Engineer, Texas State Dept. of Health.*

types of biological organisms or bacteria—and possibly both—the use of chlorine was decided upon as a means of killing these types, or at least inhibiting their activity. Experience in support of this view was had by the writer at Austin, Texas, during the spring of 1926 when, in coöperation with the Chlorine Institute of New York City, a study was made of the effect of applying chlorine to the inflowing crude sewage entering one of the Imhoff tanks. It was fairly well established that relatively small chlorine dosages applied to the sewage entering the tank reduced the tendency to foam and produced a more satisfactory tank effluent.

Use of Chlorine.—The Lufkin tank influent (crude sewage) was dosed with 20 p. p. m. chlorine, using a Wallace & Tiernan solution feed type of chlorinator. The chlorine applied caused the black liquor in the flow chamber to take on a milky appearance, due to the destruction of hydrogen sulphide and subsequent precipitation of finely divided sulphur. Owing to the high content of hydrogen sulphide the entire 20 p. p. m. of chlorine was consumed and no residual chlorine could be detected in the tank effluent by use of the ortho-tolidin test. As a result of this treatment a reduction of foaming was soon noticeable.

Realizing that the effect produced, however desirable it might be, was too expensive, it was decided to attempt reduction of the chlorine dosage. Accordingly, but 6 p. p. m. of chlorine (calculated on the average daily flow) was applied continuously to the influent (crude sewage). Within 24 hours the foaming in the tank so treated had almost entirely subsided. For two weeks this treatment was continued with successful results. With the subsidence of foaming and also attendant diminution of hydrogen sulphide in the flow chamber of the tank, as well as in the gas from the vents, the complaints from odors practically ceased.

The chlorine in no way adversely affected the final effluent. If anything, pre-chlorination improved the quality of the trickling filter effluent, which had a continuous stability of 98 per cent. The Imhoff tank effluent delivered to the filters contained less suspended matter. As expected, the tank effluent was not as putrescible, as a result of pre-chlorination, in that at least a portion of the hydrogen sulphide had been destroyed and many of the numerous putrefactive organisms. It should again be emphasized, however, that the tank effluent contained at no time any residual *available* chlorine.

Use of Lime.—It was later decided to return to conditioning the sludge and scum in the vents through application of lime—because of the greater economy and because of the success reported with the lime treatment by other investigators. For some unaccountable reason the second trial with lime again proved to be unsuccessful and within a few days foaming had increased rapidly.

Chlorination of Sludge Compartment.—A return to chlorine was made

but this time the solution was fed directly into the sludge chambers instead of into the crude influent. Although similar treatment, without success, had been previously applied to foaming tanks at Fort Worth, Texas, by Mahlie of the city of Fort Worth, and at Dallas, Texas, by Whedbee of the State Department of Health and Enslow of the Chlorine Institute, it was decided to try this method at Lufkin. A third failure of this method of dosing resulted. The failure of this treatment at Lufkin, also, would seem to indicate that reduction of foaming at this particular plant was not brought about by any chemical reactions involving chlorine. Since the reduction of foaming apparently results from feeding into the digestion compartment chlorinated solids separating out of the pre-chlorinated crude sewage, and whatever interchange exists through the slot between the chlorinated liquor in the flow compartments and the liquor in the digestion chamber, it would appear that the reduction of foaming is effected by the elimination of definite organisms entering the digestion chamber and probably also the inhibition of certain organisms already in the chamber.

Certain investigators believe that chlorine, like many other germicides, exerts a selective killing action on living organisms. It may well be that in this supposition lies the explanation of the efficacy of chlorine in eliminating or reducing the foaming of Imhoff tanks.

Having tried lime treatment and chlorination of sludge, we returned to pre-chlorination of the crude sewage at a rate of 6 p. p. m. chlorine. The results were satisfactory. A necessary shutdown of the chlorinator was followed within 10 days by foaming, but renewal of pre-chlorination stopped the foaming within 24 hours.

Later it was decided to attempt a still further reduction of the pre-chlorination dosage, this time to 3 p. p. m. Even this small dosage appeared to reduce the foaming noticeably. It should be stated that neither the 3 nor the 6 p. p. m. dosages afforded sufficient chlorine to leave any residual chlorine in the tank effluent nor was sulphur precipitation observed to any noticeable extent. The odors around the plant were nevertheless effectively reduced and the tank effluent was of more satisfactory quality than prior to the pre-chlorination procedure.

Still more interesting, perhaps, is the fact that the most recent results of the test show that it is apparently unnecessary to apply the treatment *continuously* over the 24 hours for foaming prevention alone. If, however, odor reduction is desired, continuous chlorination is more efficacious since at night odors are usually at the maximum.

The final test indicated that foaming may be controlled through the process of pre-chlorination during the period 8 a.m. to 5 p.m. daily at a rate of 3 p. p. m. chlorine calculated for the average flow in gallons per minute during the test period, which extended through 60 days of very warm and 30 days of cool weather. Through this procedure a further chlorine economy

results and so far, after 90 days trial, this procedure has proven a success with regard to foaming control at the Lufkin sewage works and that without impairment of sludge digestion.

This work has been further verified by later experiences at Breckenridge, Texas. Here, as at Lufkin, it was found both practical and economical to control foaming Imhoff tanks through chlorination of the influent.

II. Tests at Davis, Porterville and Livermore, California

BY E. A. REINKE[1]

Several studies have been made by the California State Department of Public Health, in coöperation with the Chlorine Institute, on the control of foaming and odors of Imhoff tanks. Another study was particularly concerned with the prevention of hydrogen sulphide formation with subsequent oxidation to sulphuric acid in the crown of the sewer.

The study at Davis is of particular interest as showing the advantage of knowing where the hydrogen sulphide occurs. The town has a population of 1100 and a sewage flow of 175,000 to 190,000 gallons per day. Sulphates in the water are high, almost 50 p. p. m. Sewage flows to a sump equipped with automatic pumps discharging to a force main 2600 feet long leading to the Imhoff tank and sprinkling filters. The average time sewage remains in the force main is one hour and total time from household to nozzle is about five hours.

A chlorinator was installed at the pump sump.

At the start of the work it was intended to use the reports of neighbors as an indication of odors, but their reports did not check and hence were of little value, so tests for hydrogen sulphide were chosen to give a measure of odor reduction.

Chlorine doses varying from zero to 12.5 p. p. m. were used. Reduction of hydrogen sulphide by chlorination varied from 0.8 p. p. m. for a dose of 6 p. p. m. to 2.3 p. p. m. for a dose of 9.5 p. p. m. It was concluded that a dose of 10 p. p. m. was necessary to control odors effectively at Davis, assuming that concentrations of hydrogen sulphide under 3 p. p. m. are necessary.

The most interesting feature of this study was the high hydrogen sulphide content of the sewage as it reached the plant. As stated above, the water supply of Davis has a sulphate content of about 50 p. p. m. These sulphates are reduced along the sewer lines, quantities of hydrogen sulphide

[1] *Asst. Engr., Bureau of Sanitary Engineering, California State Dept. of Public Health.*

as high as 1 and 2 p. p. m. being found at the upper end of the sewer, and as high as 16 p. p. m. at the disposal plant.

Chlorination at the inlet or at the outlet alone of the Imhoff tank was ineffective because of high hydrogen sulphide found along the line.

Hydrogen Sulphide Tests.—The work at Davis and other places indicated the necessity for a uniform test for hydrogen sulphide. The procedure given in Standard Methods of Water and Sewage Analysis gives high results in our opinion, since many iodine-absorbing substances are present in sewage.

We did a considerable amount of laboratory work, to determine the consistency of results obtained by various methods. We found that a modification of Standard Methods as suggested to us by Mr. Abernethy, Chemist, Los Angeles County Health Laboratory, gave most uniform results. The modification consists of adding 6 cc. of 1 to 6 sulphuric acid to 200 cc. of sample together with the potassium iodide crystals and iodine solution and shaking vigorously as soon as added.

In the presence of organic sulphides and possibly other substances abnormally high results would probably be obtained, but these cases are rare and from the appearance of samples the presence of excessive quantities of such substances can generally be predicted and suitable allowance made for them.

We intend to do more work on this test as well as to make a more thorough study of the factors involved in hydrogen sulphide production in sewage. These problems are critical in several localities where freedom from odors is essential.

Foaming Imhoff Tanks—Chlorination.—A chlorination study was also made at Porterville where an inspection indicated that foaming of the Imhoff tank was about to start. Subsequent inspections showed that the condition thought to be foaming was due to the inclusion of gas bubbles in large quantities of oil which the operator skimmed off the flowing-through chamber and deposited in the gas vent areas. By putting the skimmings in barrels and hauling them away for burning and by a thorough inspection of all oil and grease traps in town normal operation of the plant was restored, aside from the chlorination.

One noticeable result of chlorination at Porterville was a sloughing of the deposits in the outfall sewer when a heavy dose of chlorine was added. This indicates that it may be possible to use chlorine for cleaning dirty sewers. One operator reports the elimination of willow roots from his sewers by using chlorine in excess.

Foaming Imhoff Tank—Lime Treatment.—At Livermore, a town of 3000 population with a sewage flow of 150,000 gallons per day, Imhoff tanks have foamed from time to time. The common specific our California operators use is a strong stream of water played on or in the scum.

At Livermore this made matters worse, so treatment with lime was undertaken. It was applied dry to the scum chamber with pH control under our direction. After the pH was brought to 7.2–7.4 we found that about 100 pounds per day of slaked lime was sufficient to maintain the alkalinity. We expected that after building up a quantity of alkaline sludge in the bottom of the tank smaller doses of lime would suffice, but such was not the case, even after months of trial. If no lime was added for a period of two or three days the pH would drop to 6.6–6.4 with evidence of the start of foaming. Fortunately, the plant is well isolated and the sewer farm is on coarse gravelly soil so it was possible to by-pass the tank and allow the sludge to digest without adding any fresh solids. After a few weeks all signs of foaming stopped, but on again flowing sewage through the plant the acid condition returned. The sewage contains at various times wastes from bonded wineries, a small cheese factory, several hospitals, and illicit stills.

Sludge withdrawal after several months treatment with lime showed sludge poorly digested, the digestion apparently having been retarded by the lime. Large particles of unused lime were found mixed with the sludge. All lime was added dry except for a few days when unslaked lime was slaked on the tank and run in as a suspension. We have concluded that any additional treatment should be done by solution feed to get the maximum use of the lime, but we are not yet certain that lime treatment is the solution for the problem.

[*Editor's Note.*—The following abstract from a recent article in *The Surveyor* describes experiences with the control of odors by chlorine in England.]

Sewage Chlorination and Sludge Digestion at Bath, England. F. P. SISSONS. *The Surveyor*, **74**, 31 (July 13, 1928).—The sewage works at Bath have in the past been responsible for a serious odor nuisance over contiguous areas. Conversion of the plant to the separate digestion type went a considerable way toward elimination of odors. Following this improvement, however, there were periods when complaints of nuisance from odors were justified.

Careful observations and investigation identified hydrogen sulphide production to be the true source of the remaining odors liberated at the plant. The major source of hydrogen sulphide production was found to be the breaking down of sulphates in the crude sewage, as it traveled through a 30-inch riser main to the works about 5 miles distant from the pump station. Consideration was given to the possibility of installing a smaller main or placing a liner in the existing main in order to increase the rate of travel and decrease the time the crude sewage might require to reach the works. The estimated expense appeared prohibitive and instead chlorination of the crude sewage was given a trial.

In an attempt to retard the growth of organisms which produce hydrogen sulphide partial sterilization of the sewage was attempted. Chlorine was applied at the crude sewage pumping stations. After two years functioning of the chlorination process, results in odor correction have far exceeded expectations, when consideration is given the small quantity of chlorine applied. Complaint has been practically eliminated, with the exception of a few isolated instances.

The chlorine dosage is increased during low dry-weather flow, which is the period when ordinarily the worst complaints are received. During periods when complaints are ordinarily not to be expected the chlorine application is reduced or entirely discontinued. The average dry-weather flow is 3 m. g. d. The sewage is chlorinated at a cost of £600 per annum (approximately $3000). Thus the cost of chlorination is roughly $2.70 per m. g. treated per year to render the plant free from serious odor production.

The treatment works consist of detritus tanks, settling tanks of the Dortmund type, circular percolating filters with revolving sprinklers, humus tanks of the Dortmund type, and primary and secondary rectangular digestion tanks operated in series. Each Dortmund tank is completely emptied of sludge daily.

A Flotation-Type Nozzle for Sewage Treatment

BY FREDERICK G. NELSON[1]

A flotation-type nozzle has been designed and perfected to meet the requirements for uniform distribution of sewage on trickling filters. The underlying principle of the floating cone was discovered by Charles Gilman Hyde, Dean of Sanitary Engineering at the University of California, while experimenting in an endeavor to design a low-head nozzle for aeration of water at the purification plant at Sacramento, California. A nozzle employing this principle was designed and put in operation at the Sacramento plant, as described in *Eng. News-Rec.*, **89**, 384 (1922), by Harry N. Jenks.

Modification of Nozzle Used for Aeration of Water.—Professor Hyde suggested the possibilities of this type of nozzle for use in sewage treatment, and it was under his direction in 1923 that the writer undertook to develop it for that purpose. The most essential factors in the design were: (1) that provision be made whereby the spray would have a maximum throw, and (2) that the quantity discharged per minute be kept at a low rate. In order to accomplish these results it was necessary to increase the angle with the vertical at which the liquid leaves the nozzle, and also decrease the diameter of the throat. A 45° angle was taken as

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the one giving the maximum throw, while a 1-inch diameter throat opening was selected. This design differed materially from the Sacramento design, with its 30° angle, and a 2-inch throat opening.

Difficulties were encountered with the first design because of chattering under practically all heads, but one was finally worked out which gave fairly good results during the time the experiments were being conducted in 1923. The nozzle developed at that time, however, was too large and too sensitive to be of practical use.

The design has recently been perfected, as shown in Fig. 4, and the desired results obtained. It was worked out on the theory that if the water struck the cone as a jet the velocity head would tend to keep the cone in equilibrium. In order to prove this theory another nozzle was made exactly like the one shown, except that it had a more gentle flare in the base portion. Water being discharged from it tended to cling to the sides of the ball, and when the cone was put in place it lost its equilibrium and crowded over to one side, allowing the water to be discharged on the opposite side only. This is not the case, however, with the final design. The cone remains in perfect equilibrium at all heads, allowing a uniform discharge around the entire circumference of the nozzle.

Varying the weight of the cone made very little difference in the discharge. Different lengths of spindles varying from 4 inches to 12 inches were used with approximately the same results, 6 inches being adopted as the most practical length.

Rate of Discharge.—Figure 1 shows the discharge per minute under heads of $^3/_4$ foot to $5^1/_2$ feet, for the $^7/_8$-inch and the 1-inch nozzles, respectively, both having a $^3/_8$-inch spindle on its cone. It will be seen that the discharge falls off to a very low rate on the low heads. A perfect spray is given at these low heads, continuing until the cone seats, entirely shutting off at the low heads, as shown on the diagram. No dribbling occurs as the discharge ceases.

Distribution of Spray.—Figure 2 shows the distribution of the spray, in gallons per square foot per minute, for each of the heads as indicated at the peak of the curves. Figure 3 has been plotted to show a typical distribution curve along the line between two nozzles properly spaced for net heads from 1 foot to $5^1/_2$ feet. The curve is based on the assumption that the head drops at a uniform rate. If these curves are compared with similar curves for nozzles now in use it will be observed that these now on the market give a severe overdose on the inner rings of the circle when allowed to discharge at the lower heads, while the flotation type gives only a slight overdose at the lower heads.

The flotation type nozzle can be designed to meet many special situations. Excellent results are obtained by plugging the proper portion of the throat to produce a half-nozzle. The nozzle can be made in any size so as to

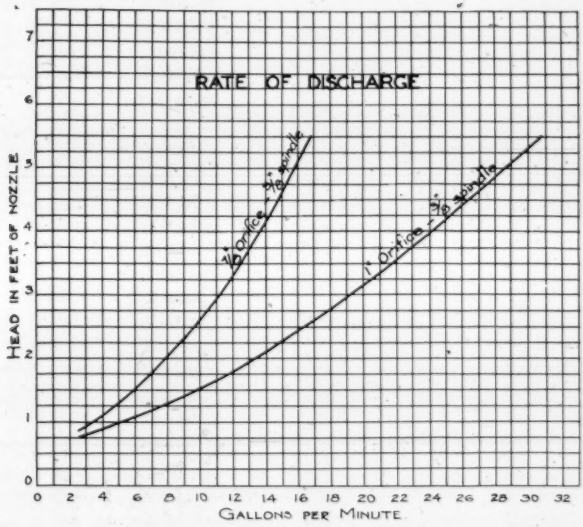
RATE OF DISCHARGE
HEAD IN FEET OF NOZZLE
GALLONS PER MINUTE
½" ORIFICE - ⅜" SPINDLE
1" ORIFICE - ⅜" SPINDLE
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
0 1 2 3 4 5 6 7

FIG. 1.—Rate of Discharge.

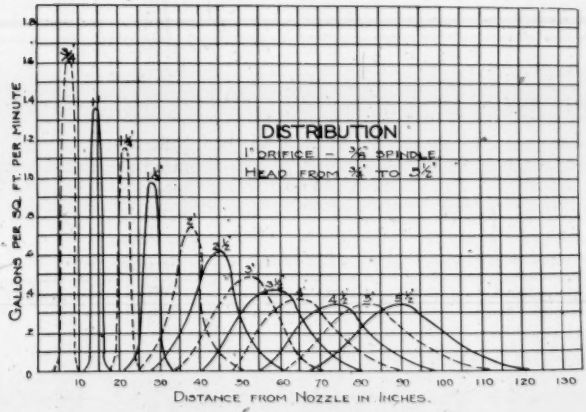
DISTRIBUTION
1" ORIFICE - ⅜" SPINDLE
HEAD FROM ½ TO 5½
GALLONS PER SQ. FT. PER MINUTE
DISTANCE FROM NOZZLE IN INCHES.
10 20 30 40 50 60 70 80 90 100 110 120 130

FIG. 2.—Distribution for Various Heads.

have the desired capacity. The design of the base casting determines to some degree the shape of the spray.

Operating Results.—If the nozzle is used on open filters in cold climates the cone has a tendency to freeze to the bell during rest periods. How-

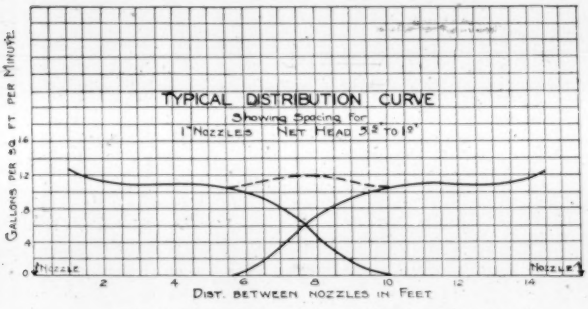

FIG. 3.—Typical Distribution for Two Nozzles.

ever, this has been overcome by placing three small beads on the underside of the cone when the nozzles are used in cold climates. The beads separate slightly the cone from the base when it is seated, thereby allowing the standing liquid to drain back into the riser pipe before it has had time to freeze.

Some field information has been obtained by installing a few on operating trickling filter plants. On March 23, 1928, four of the 1-inch diameter nozzles were installed in the filters at Ames, Iowa. They were placed at the points where the operator reported most trouble from clogging. They were operated continuously until June 11th, at which time they were removed to be used at other plants. On at least two occasions during the two and one-half months of operation the temperature dropped to 15° F., but the nozzles did not freeze, although no beads had been placed on the cones to prevent them from seating

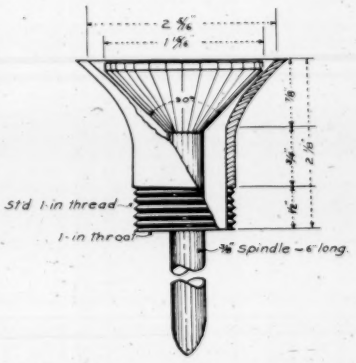

FIG. 4.—"Flotation-type" Sewage Nozzle.

tightly. The operator reported that it was necessary for him to remove only a couple of the nozzles for cleaning during the entire period of operation, while it had been necessary to clean at these points once or twice each day prior to this time.

A short test was made with a $^{7}/_{8}$-inch, and a half-spray nozzle placed on the plant at Boone, Iowa, with results comparable to those obtained at the Ames plant. In order to see how effective the smaller design was in passing obstructions ten matches were placed in the riser pipe. After one discharge on the filter bed the nozzle was removed and the contents of the riser pipe examined, only one match being found. The nine matches had been discharged without causing a break in the spray.

Conclusions.—In closing the writer wishes to summarize the principal advantages of the flotation type nozzle:

(1) Clogging is practically eliminated.

(2) If clogging does occur it is necessary only to lift the cone in order to remove the obstruction.

(3) The parts are simple and rigid, and will not get out of order after being in use for a few years. The discharge characteristics will not change with age.

(4) Better distribution of sewage on the filter bed is obtained than with types now on the market.

(5) The spray is thrown for a greater distance than for many other types of nozzles.

(6) Half-nozzles can be easily constructed and tend to give a uniform spray.

Acknowledgments.—The first experiments leading to the development of the flotation type nozzle for sewage purification were conducted under the direction of Professor Charles Gilman Hyde. Valuable suggestions were given by Harry N. Jenks, Associate Professor of Civil Engineering at Iowa State College.

Simple Applications of Fundamental Principles of Sewage Treatment

BY C. G. GILLESPIE[1]

Two practical methods for the disposal of small volumes of sewage have come to the attention of the writer. In both cases rather crude but ingenious schemes were adopted at very slight cost, obviating large expenditures for standard types of treatment plants, and at the same time solving the sewage disposal problem without nuisance or complaint.

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The Carmel Sanitary District of California was faced with the problem of disposing of its septic tank effluent several years ago. This tank was built in the coarse sand dunes of one of its beaches, on a blue gem of a bay. The effluent ditch, which formerly discharged directly into the bay, was filled with sludge and overgrown with weeds so that the septic effluent dribbled to the sea over the beach, creating odors and a nuisance throughout its entire course.

A proposal for dispersal through a tunnel to the deeper water was very costly, running over a million dollars. An activated sludge plant for inland disposal was also excessively expensive. The population of the District was approximately 4000 with a flow of sewage varying from 50,000 gallons per day in winter to 80,000 g. p. d. in summer.

The President of the District, Dr. William Tower, modified an idea of the writer's in such a way that the problem was solved successfully and at a very low expense. The original idea was to parallel the shore with a long, narrow, open cesspool in the sand dunes. Check weirs were suggested for retardation of flow, but Dr. Tower laid out the pool in such a way that it formed a series of terraces, 15 ft. wide and 20 ft. long, sloping 4 inches, in their length of 20 ft., to 2 by 4 in. nosings. There were two units of these terraces made up of five steps of 15 by 20 ft. each, or a total of 3000 square feet.

When the beds were put into use it developed that the slope of the surface was just sufficient to cause some movement of the sand grains. The sand was very coarse, resembling a fine graded concrete sand, with approximately 0.3 mm. effective size and 2.5 to 3.0 uniformity coefficient. The rolling movement of the grains cut away or loosened most of the slimy covering which would usually seal a sand bed in a short time if dosed at this high rate. The sloping surface aided the flow of sewage and scouring action of the sand.

One set of terraces takes the sewage flow for a week easily, there is no ponding, and the sewage sinks away in a few seconds after it is shut off. The sand can be immediately raked over or resurfaced. The water plane is 10 or 12 feet below the surface.

Another novel feature of this plant is a separate sludge digestion tank for partially digested sludge from the septic tank.

Another case where advantage was taken of unique local conditions occurred at the town of Vacaville, California. Effluent from its septic tank was creating a nuisance in a nearby gulley. Investment in a trickling filter would have been quite expensive. The town engineer suggested that it might be possible to pass the settled sewage over the local sewage farm in such a manner that it could be stored in ponds without nuisance during the dry months.

Following his suggestion the septic tank effluent was run into a header

ditch, into the banks of which were inserted a number of pipe ports at intervals of 15 or 20 feet. The clarified sewage was released through these ports in a thin sheet which flowed through a thick growth of grass down a slope of about 1 foot per 100 feet. The soil was quite unfavorable, being the tightest of gumbo or adobe, so that it is doubtful if much of the sewage soaked into the ground, but most of it was undoubtedly lost by evaporation and use by luxuriant growth of grass.

The sewage flow is about 125,000 gallons per day, the area of the farm 8 acres. The ponds hold 3.5 million gallons. In the eight months dry period, when the sewage must be held back, some 30 million gallons of sewage was discharged but not more than 3 million gallons ever accumulated in the ponds.

The effluent after passing over the sloping farm and before entering the ponds appeared to be equal to a trickling filter effluent. It did not putrefy nor become a nuisance in the impounding ponds.

This simple solution of Vacaville's problem utilized some of the fundamental principles of sewage treatment, namely, removal of colloids by the straining action of the heavy growth of grass, aeration and re-aeration by absorption of oxygen in thin sheets, and finally photosynthesis by prolific growth of algae.

Experiences and Experiments at the Houston Activated Sludge Plants

BY G. L. FUGATE[1] AND W. S. STANLEY[2]

Excerpts from papers presented at the Ninth and Tenth Meetings of the Texas Sewage Works Association, January, 1927 and 1928.

Ninth Meeting, January, 1927

The earliest sewage treatment experiments with activated sludge in Houston were conducted over a period of about two years, during 1914 and 1916. Two large plants were designed and constructed based on the data of these early experiments. The experimental work did not stop when these plants were placed into operation, but has continued to date.

The first experiments established a great many factors that have proved during ten years operation of the large plants to be fundamentals of the process. Among these may be mentioned the air requirements.

Air Requirements.—The early experiments proved that when the quantity of air supplied was less than 0.2 cubic foot free air per square foot of water surface per minute there was a noticeable falling off in the results.

[1] *Asst. City Engineer.*

[2] *Chemist, Sewage Treatment Works.*

When the amount of air per square foot per minute was in excess of 0.25 the improvement was not proportional to the quantity of air supplied, and therefore uneconomical. It was also established, by aerating sewage in experimental tanks at different depths, that the best agitation with reasonable amount of air was obtained with a depth not less than 7½ feet; with shallower tanks there was not enough agitation unless the quantity of air was increased. These tests proved that the depth is not of paramount importance as far as cost of air is concerned.

Two activated sludge plants were constructed in 1916 of a combined capacity sufficient to care for Houston's estimated requirements for ten years. Of these plants the smaller one (South Side Plant), serving a purely residential section, is still working at less than its capacity, while the larger one (North Side Plant), receiving sewage from business, manufacturing and parts of residential sections, is now somewhat overloaded and has been since January, 1926.

Clogging of Filtros Plates.—The early experiments cast some doubt upon the permanence of the air diffusion plates, but the chief trouble that developed in the large plants from the clogging of the plates was caused by the manner of placing the plates in cast iron holders. They were completely clogged in a short time by iron rust.

Laboratory tests indicated that the rust could be effectively removed by immersing the plates for a few hours in 10 per cent solution of hydrochloric acid. The plates were taken out of the holders, by breaking away the iron castings, rinsed and replaced in concrete holders. About 25 per cent of plates were lost through breakage.

This change practically solved the rust problem, as the velocity of the air through the pipes is so low that very little rust forming in the pipes is carried to the plates. With the later information on operation it is now believed that with concrete holders and dust removers, through which the air is cleaned, the life of the plates will be not less than five years and in some places considerably more.

Disposal of Activated Sludge.—The next problem, which at present seems to be just past an experimental stage, is the disposal of excess sludge.

The lagooning of sludge, which is but another form of separate sludge digestion, is now used, but has not been altogether satisfactory and has been considered a temporary method.

Activated sludge as produced in Houston has such high water content that a large volume of liquid must be removed; this liquid, coming in contact with the digesting sludge, is high in organic matter, having a five-day biochemical oxygen demand of around 900 p. p. m. This liquid, if returned to the plant, is more difficult to treat than the original sewage, thereby decreasing the actual capacity of the plant.

Because of dissatisfaction with lagooning attention was turned to the

dewatering of activated sludge, with the object of obtaining a stable effluent and dry solids in a condition suitable for commercial fertilizer.

Various methods have been tried, the first in October, 1917, along the lines of the now-forgotten process called "flotation." The process used soda ash and sulphuric acid with application of heat to evolve bubbles of carbon dioxide; the entrainment of this gas was expected to separate the solids by floating them to the top of the liquid. The best results were obtained with 105 pounds soda ash and 268 pounds sulphuric acid per ton of dry product, at a temperature of 45 degrees C. The resulting sludge, however, had about 97 per cent water. Because of such high moisture content it was obvious that this method would not be practical.

The World War brought about such unsettled economic conditions that very little more was done towards dewatering of sludge until December, 1920. In January, 1921, a dewatering plant was put into operation. This plant consisted of three cypress sludge-settling tanks of 50,000 gallons capacity each, two plate-and-frame filter presses and one direct-indirect heat rotary dryer. It was expected at that time that this plant would have a capacity of ten tons of dry sludge per day.

Experiments on Filtration of Sludge.—Attempts were made to filter the sludge as received from the aerating tanks, also after acidification with sulphuric acid and sulphur dioxide gas. Comparative runs indicated that with plate and frame presses little difference in final cost of the product was obtained, the net cost per ton, retail value, being:

Unconditioned sludge	$38.90
Conditioned with sulphuric acid	33.85
Conditioned with sulphur dioxide	39.30

On account of the high cost of labor for operation of the filter presses and the short life of filter cloth the use of the plate and frame presses was abandoned.

A standard wet machine used in paper pulp industry was then installed. Sulphur dioxide gas was used for conditioning. While this machine gave very high filtration rates and looked very promising, certain mechanical troubles developed which brought about the installation of the "Decker" type machine, a modification of the standard wet machine.

The greatest disadvantage of the pulp machines was the loss of solids passing through the screen. The cost of replacement of the wire screen and felt blankets was quite high, and in general non-consistent results as to capacity were obtained.

To control the optimum filtering condition, the acidity of the sludge was determined by titrating the sludge to be filtered with standard alkali. The best results were obtained when a 0.1 *N* solution of potassium hydroxide gave an end point at 14 cc., using 100 cc. of sludge for determination.

More recent experiments have been conducted with a 4-foot American continuous vacuum filter using either aluminum sulphate or ferric salts as conditioning reagents. For control of the conditioning the hydrogen ion concentration was used as a guide in place of titration. Positive and delicate means of synchronizing the flow of sludge and conditioning solution were perfected. This enabled absolute control of the plant operation. In consequence, the results obtained were consistent and justified a large installation (installed in 1928). Optimum filtration of the sludge was obtained with aluminum sulphate at a pH of 4.8 and with ferric chloride at 5.4, by the colorimetric method of pH determination.

It is expected to produce a sludge cake containing from 80 to 82 per cent of moisture at a cost within economic limits. The cake in this condition can be readily dried through the rotary dryer, although the rate of evaporation per pound of combustible is much less than on most other materials.

The experiments indicate that the sludge at Houston is one of the most difficult to dehydrate of any so far encountered, but by the above process it is also indicated that the dehydration may be completed within the selling price of the dried material.

In the spring and summer of 1926 a process was tried which consisted in treating sludge with a conditioning agent and running the treated sludge on drying beds for partial drying; the patentee of this process expected to complete the drying by exposing the material to the atmosphere by placing upon racks or in heat dryers. This process proved unsuccessful in Houston. Climatic conditions and other factors caused bad odors and other nuisances before the sludge had time to dry sufficiently to be removed from beds.

Anaerobic Sludge in Settling Tanks.—The contemplated enlargement of the North Side Plant prompted additional research. It has been long realized that the settling tank which must be used after aeration of the sludge is the critical point and controls the successful operation of an activated sludge plant. With deep hopper-bottom tanks as used at Houston this control is greatly complicated by the inability to prevent a concentrated sludge from decomposing in the settling tanks and thereby losing its aerobic condition.

It was our belief that bacterial action in the sludge in the bottom of the settling tanks was possibly the cause of rising sludge blankets with consequent intermittent loss of sludge in the effluent and more or less continuous rising and discharge of small quantities of sludge.

Based upon the above assumption an attempt was made to retard anaerobic action in the settling tanks by prechlorinating the tank influent with small dosages of chlorine. With all dosages of chlorine less than sufficient to produce residual chlorine in the effluent no improvement of the func-

tioning of the settling tanks was observed. Neither was there any detrimental effect observed until excessive dosages of chlorine, producing residual chlorine, were applied. At the latter stage the suspended solids in the effluent increased materially above the non-chlorinated tank effluent.

These chlorination experiments lacked the careful control which was desirable and the bacteriological laboratory work was more or less unsatisfactory; therefore no final conclusion should be drawn from this experiment. Further experiments are contemplated.

Experiments on Packinghouse Wastes.—It has been observed that a packinghouse waste having an alkalinity of 875 p. p. m. and chlorides of 3000 p. p. m. will decompose during aeration and that the higher organisms found in a well-activated sludge are absent after prolonged aeration.

Experiments with very concentrated packinghouse waste indicate that surface aeration by mechanical apparatus is equal in cost of power to that of diffused air. Standard purification was accomplished by the first method in 36 hours as compared with twelve hours using diffused air. With normal domestic sewages, however, it may be possible to obtain greater power economy using surface aeration.

Effect of Iron on Activation.—To determine the effect of iron content of sludge on purification, two tanks were operated in parallel. To one, iron was added in such amounts as to bring the total iron in sludge to 6 per cent, dry basis; the other tank was operated with normal sludge. When the tanks were first started with normal sewage there was a noticeable increase in volume of sludge in the tank containing iron and a corresponding increase in clarification of effluent. Nitrification proper, together with reduction in B. O. D. did not start any sooner in the tank containing iron than in the other one. Evidently as far as Houston conditions are concerned iron content of sludge has no effect on purification.

During these tests a very close check was kept on the amount of excess sludge produced during the process of aerating normal sewage, compared with the incoming suspended solids. It was found that the digestion of solids in aeration tanks amounted to 49.8 per cent as compared with figures formerly computed from operation data of large plants as 51.7 per cent. This gives a very close check between the experimental unit and the actual operation of the large plant.

Tenth Meeting, January, 1928

This paper deals with further experiments on the dewatering of activated sludge at Houston.

Failure of Lagooning.—Up to 1920, the only means of disposal of excess activated sludge was lagooning. It has been repeatedly observed that

when the pH of sludge in lagoons falls below 7.0 a thick crust of undigested solids forms on the surface, accompanied by a highly offensive odor. This can be remedied in most cases by hosing the lagoon with fire hose. Aggravated cases were known to persist for ten days or more, and were alleviated only by persistent stirring and hosing. The addition of lime would doubtless help, but the cost of such procedure makes its use out of the question.

The failure of lagooning made it necessary to turn toward a method free from its objectionable features. Such a method was considered to be filtration, yielding a stable effluent and a salable solid material.

The filtering installation at the North Side Disposal Plant will consist of sludge conditioning equipment and an American vacuum filter.

Requirements for Successful Filtration.—Activated sludge, to be successfully filtered, must conform to certain requirements:

1st. As the sludge will not filter well in its raw state, it must be conditioned by means of some chemical. The conditioner must be added in the right amount to insure proper pH.

2nd. The sludge must be well aerated. An improperly aerated sludge will not filter well no matter what its conditioning.

3rd. It must not be septic. The fresher the sludge, the less conditioner it requires and the better it filters.

4th. There must be as little agitation as possible after addition of conditioner.

To insure freshness sludge will be brought directly from settling tanks and filtered immediately, without storage.

To insure proper conditioning a sludge feeder of the bucket wheel type and a conditioner solution feeder of the same type will be installed, both operated by the same countershaft, and so arranged that the proportion of conditioner to sludge when once adjusted will not vary, no matter how the speed of filtration varies, unless adjusted again by the attendant.

The pH of conditioned sludge will be checked by both the colorimetric method and by measuring the electrical resistance of the solution conveying the sludge to the filter. In the latter method there will be employed a recording milliammeter, which will give a continuous and permanent record of the degree of conditioning.

In order to allow the sludge to mix intimately with the conditioner without being violently agitated a long baffle box with alternating over- and-under baffles will be employed. This will insure a large, well-formed floc, such as is necessary for best filtration.

Selection of Conditioner.—The selection of the conditioner seems to be one of the most important factors of the whole process of sludge dewatering. Sulphur dioxide gas and sluphuric acid gave indifferent results at Houston, while aluminum sulphate and chlorinated copperas were effi-

cient and the choice between the two is only a question of price. It was consequently decided to install suitable equipment for chlorinating copperas, as well as storage facilities for handling aluminum sulphate.

The pH at which Houston activated sludge filtered best was as follows:

1. For sulphur dioxide, pH between 3.2–3.6.
2. For sulphuric acid, pH 3.4.
3. For aluminum sulphate, between pH 4.4 and 4.8.
4. For chlorinated copperas, pH 5.4 was the optimum point.

It was found that at a high pH "mudding" of the cloth occurred. This was caused by wet sludge smearing over the surface of the cloth and stopping filtration. On the other hand, low pH caused "white spotting." This was a peculiar condition of cloth where the conditioner used acted as a mordant and fixed certain colloidal substances in the pores of the cloth, thus checking the rate of filtration. Both conditions were quite detrimental to the successful operation of the filter.

The speed of the filter depends upon the condition of sludge. The best results were obtained in Houston at a speed of one revolution per twelve minutes.

The kind of cloth to use for filtering medium has not yet been determined. We have used Palma twill and burlap cloth with equal success as far as the rate of filtration is concerned. The wearing quality of Palma twill is the only argument in its favor. Woolen blanket cloth will also be considered.

The drying of cake obtained by filtration did not present serious difficulties when the moisture was kept below 85 per cent. There was therefore no reason for immediate research in this direction. All energy was centered upon the filtration problem. This being successfully solved, the next step will be the study of drying conditions. With this in mind, a recording pyrometer and a recording hygrometer will be installed to study and record both the temperature in the dryer and the humidity in exhaust gases.

Industrial Wastes and Stream Pollution

Improvements in the Operation of a Textile Wastes Treatment Plant

By Stuart E. Coburn[1]

General.—An interesting problem in the treatment of textile wastes, resulting from changes in the character of the wastes, has been met and solved at one of the mills of the American Woolen Company. The manufacturing processes consist of spinning, weaving, dyeing, and finishing woolen blankets. The liquid wastes from the last two processes require a high degree of treatment before discharge into an adjacent water course on account of the fact that other textile mills down-stream utilize the stream waters for bleaching and dyeing processes.

Volume of Wastes.—The mill discharges approximately 450,000 gallons of liquid wastes each day, composed principally of spent dye liquor from the dye-house, washer wastes and rinse waters from the wet finish and sewage from the mill toilets.

Character of Wastes.—The combined wastes from the mill are highly colored, exceedingly turbid, and contain a considerable quantity of soluble solids, soap, dirt, wool fibre, and oils.

Treatment.—The wastes are treated with a precipitant and settled. All of the settleable solids and much of the colloidal solids are removed while the color and turbidity are greatly reduced.

The settled wastes are then applied to intermittent sand filters. The effluent produced is practically clear and colorless, has only a slight musty odor, and is perfectly stable at all times by the methylene blue test. On the whole, the effluent is better than the stream into it which is discharged.

Description of Treatment Plant.—A drainage system collects the wastes from the dye-house, wet finish, mill toilets, and wash-rooms, and the sewage from a number of mill tenements. The combined wastes flow by gravity to the treatment plant.

The wastes from the wet finish pass through a rack screen which holds back a considerable quantity of flocks of wool. This rack is hand raked and the flocks removed are washed, dried, bundled, and sold as a filling for mattresses. An investigation is now under way to determine their suitability for use in the manufacture of sound-proofing materials.

[1] *Chief Chemist, Metcalf & Eddy, Engineers, Boston, Mass.*

The treatment plant consists of sedimentation tanks, sludge drying beds, and intermittent sand filters.

There are 5 sedimentation tanks, each roughly 30 ft. wide, 100 ft. long, and 4.3 ft. deep, having a total capacity of 615,900 gallons. Four sludge beds having a total area of approximately 0.53 acre are available for dewatering the sludge. The filter beds are six in number and have a total area of approximately 4.0 acres, each being about 4 ft. deep and properly underdrained.

Troubles in Operation.—When the treatment plant was first put into operation, a high-grade, all-wool blanket was being manufactured, a product which was treated with a solution of aluminum chloride for "cloth carbonizing." Part of this carbonizing liquor was lost in the extractors and was discharged to the sewer. The stock solution of aluminum chloride was also discharged when it became too dilute or too dirty for further use. This liquor acted as a precipitant and assisted materially in the clarification of the wastes. Later the cloth carbonizing of the blankets was discontinued, resulting in the abandonment of the use of aluminum chloride. Clarification became very much poorer in the absence of a coagulant. This condition was corrected by the replacement of the aluminum chloride by an equivalent quantity of aluminum sulphate.

Later there was a change in the quality of blankets being manufactured. Instead of a long-fibre, all-wool blanket, a cheaper grade was produced. The stock used in the new blanket was dirty, oily, had a short fiber, and the wastes produced were of such a character that large quantities of aluminum sulphate had no appreciable effect. The effluent from the settling tank contained practically no settleable solids but it was highly turbid and contained colloidal matter that sealed the surface of the filter beds, necessitating cleaning after the application of each dose.

Improvement of Operation.—An investigation revealed the fact that the change in quality of the stock had caused a change in the washing process. Increased quantities of soap and soda were required to remove the dirt and oils, and the resulting wastes were highly alkaline. They also contained a larger quantity of organic solids.

Laboratory tests showed that by increasing the hydrogen-ion concentration of the wastes with sulphuric acid to a pH of about 6.0 before the addition of alum, it was possible to obtain a large quick-settling floc that left a well-clarified top water.

In order to make the test upon a working scale a wooden tank with a revolving wooden paddle was constructed just below the rack screen and a mixture of a solution of aluminum sulphate and sulphuric acid in the proper proportions was applied to the wastes from the wet finish. The flow of chemicals was regulated according to the character of the wastes, with the result that good clarification was obtained at all times.

By regulation of the hydrogen-ion concentration of the wastes on a full working scale, it was found that the quantity of alum required was decreased, the size and rate of settling of the floc was increased, and the resulting sedimentation tank effluent was better than that produced before the production of the cheaper grade of blanket.

Directly after the change in treatment was made the filter beds were cleaned. Since then it has been found that instead of cleaning after each dose, it is possible to operate the plant with but two cleanings a year. These cleanings take place in the fall prior to furrowing the beds for winter operation and in the spring before leveling the furrows.

If winter conditions permitted this plant to be operated without furrowing, it is safe to say that the periods between cleanings would be even longer.

Summary

With a changed character of the wastes from this mill, it was found that by adjustment of the pH of the wastes to a value of about 6.0, excellent precipitation could be obtained.

As a result of the improvement in sedimentation, a very material improvement was brought about in the operation of the intermittent sand filters.

Treatment of Laundry Wastes[1]

BY L. E. SAKERS AND F. M. ZIMMERMAN[2]

Ordinarily laundry wastes cause little concern in communities equipped with a modern sewerage system, but when no sewage treatment works is available the discharge of laundry wastes into adjacent bodies of water may cause some difficulty.

About two years ago one of our neighbors complained that the effluent from our laundry was causing the death of chickens and ducks which drank from Dead Run below our plant. As a result of this complaint, we were enjoined by the courts to place into service some type of waste treatment plant, although the State Department of Health had taken no action against us.

Laundry Process.—Our plant operates twelve hours per day for the first three days of each week, handling approximately 8700 pounds of wet wash during this period. This wash is divided into batches of clothes of which 80 per cent are white and the remainder colored. During the

[1] *Presented at Second Annual Conference, Maryland Water and Sewerage Association, Baltimore, April 11, 1928.*

[2] *Proprietors of Franklin Wet Wash Laundry, Woodlawn, Maryland.*

week about 300 pounds of soda, 200 pounds of soap chips and 130 pounds of chlorine solution are used. Each batch of clothes (240 pounds) is subjected to a thorough washing and a number of rinsings, making a total of 7 discharges of wash and rinse water for a batch of clothing. Total water consumption is 850 gallons per hour. The wastes consist of soapy water, dyes, grease and dirt from the clothes. They do not include any human sewage.

Laboratory Experiments.—In September, 1926, we engaged Wiley and Company, Inc., of Baltimore, to investigate our problem and recommend the proper type of treatment for the wastes. Laboratory coagulation experiments were conducted by this company with alum alone, alum plus sulphuric acid, sodium aluminate and a combination of iron and lime. Iron and lime produced the best floc and proved to be the most satisfactory coagulants. It was recommended by this company that two tanks, 15 feet by 30 feet in plan and ranging in depth from 6 to 7 feet between the shallow and deep ends, be installed. The iron and lime were to be added to the wastes from the tubs as they discharged into one of the tanks, it being recommended that the tanks be used alternately. A sludge draw-off line was provided at the bottom of the tank.

Plant Experiments.—Our actual experiments with the treatment of the laundry wastes on a plant scale began in February, 1927, with the use of a Cunningham filter. This device consists of layers of gravel and sand. The surface of the sand is scraped by means of revolving discs which rake the surface accumulations to a center discharge cone. The laundry wastes were first treated with iron and lime and then discharged onto the filter. This filter did not operate satisfactorily, because of the rapid clogging of the surface of the sand.

We then undertook studies with two flat-bottomed sedimentation tanks, which were 5 feet 6 inches square and 4 feet deep. Throughout the entire period of experimentation the iron and lime have been added to the influent channel. By this arrangement all of the discharges from the laundry tubs, of which there are two, pass through and mix with these chemicals, which are added at intervals throughout the day in proportion to the quantity and condition of the tub discharges.

During the first stages of tank treatment, the chemically treated raw waste passed through the two tanks in series. It was found that the first tank was short-circuiting and, as a result, the effluent from the combined tanks was very high in suspended material. A barrel was then installed in the first tank to serve as a stilling tank, after which a better mixture of chemicals and wastes resulted. The combined material then flowed over the weir into the second tank which still short-circuited to some extent. A center well placed in the second tank still did not prove entirely satisfactory, so a third tank consisting of a circular excavation in the ground lined with stone was placed in service. At times of maximum

flow, the period of sedimentation was still insufficient in this third tank.

A cinder filter bed 30 by 33 feet in area was installed for final treatment. This bed was not equipped with underdrains, but had two blind ditches installed at right angles to which the bottom of the bed was graded. The bed was filled with 15 inches of large stone over which were placed 4 inches of clinker then 4 inches of gravel and over this from 5 to 6 inches of screened cinders and on top 4 inches of sand. The wastes from the three tanks were distributed upon the cinder bed by a wooden trough with holes bored in the side at 1 foot intervals. It was found that the effluent of this bed was quite satisfactory, when efficient settling was obtained in the tanks.

In order to improve sedimentation an agitator was placed in the first tank and the center well removed from the second one. The agitator was an old wagon wheel driven from the shaft which drove the laundry tubs. This method of agitation produced an excellent floc and effected a reduction in the amount of chemicals used.

Chemicals Used.—Throughout most of the experiment approximately 15 pounds of lime and 5 pounds of iron sulphate were used per thousand gallons of waste. These quantities were reduced to 10 and 2.5 pounds, respectively, with better agitation and sedimentation. At 0.6 cent per pound for lime and 2.5 cents per pound for iron, this is equivalent to 12.25 cents for each thousand gallons of wastes treated. This cost can be reduced by buying the chemicals in larger quantities. We believe, however, that these figures correspond favorably with the cost of treatment of average laundry wastes as reported by Mr. F. E. Daniels in connection with his experiments at the Mont Alto Sanatorium in Pennsylvania.[3] Mr. Daniels reports the costs of chemicals per 1000 gallons of waste treated as 28, 24 and 7.3 cents, respectively, for the acid-lime, iron-lime and acid-alum methods.

Sludge Handling.—In the early stages of these experiments sludge was deposited on the ground adjacent to the sedimentation tank, but upon recommendation of the State Department of Health, a bed 9 by 15 feet in area was filled with 1 foot of graded cinders. This was underdrained with ordinary farm tile. Sludge placed upon this bed would dry under normal summer conditions in 2 days. The sludge, amounting to 60 cubic feet per week, is now run directly onto the bed by removing a plug in the bottom of Tank 2. An analysis of this sludge showed it to contain 2.6 per cent grease and 1 per cent nitrogen. Although this analysis would not indicate that the sludge has much fertilizer value, we have nevertheless obtained pleasing results from its use in our gardens and on our lawns.

Results Obtained.—Composite samples were taken on five different days from the raw, settled and filtered wastes. Analyses of these samples in

[3] *Public Works*, **54**, 6 (1923).

the laboratories of the Maryland State Department of Health gave the following results (Table I).

TABLE I

ANALYSES OF SAMPLES FROM TREATMENT OF LAUNDRY WASTES

(Results in Parts per Million)

	Turbidity	Color	Total Solids	Suspended Solids	Oxygen Consumed
Raw	700	225	3175	1150	828
Coagulated and settled	225	140	1690	357	179
Filtered	50	80	1065	38	89
Over-all reduction, per cent	92.9	64.4	66.5	96.7	89.3

A number of determinations on the stream above the laundry discharge and approximately one-quarter of a mile below show the median turbidity to be 20 p. p. m. at each station. The color is 35 p. p. m. up stream as against 40 p. p. m. down stream. The total solids and oxygen consumed figures are 147 and 31 p. p. m., respectively, above the plant discharge as against 155 and 35 p. p. m. at the station one-fourth of a mile down stream. These data indicate little if any effect on the stream caused by the treated laundry wastes.

Acknowledgments.—The writers wish to extend their thanks to Mr. T. C. Schaetzle, Senior Assistant Sanitary Engineer of the Maryland State Department of Health, for his assistance rendered in the preparation of this paper and to Mr. Abel Wolman, Chief Engineer, for his review and helpful criticisms. We desire to extend our thanks also to the other members of the Engineering and Chemical Bureaus of the Maryland State Department of Health for their help in collecting and analyzing the samples which are the basis of the efficiency figures offered in this paper.

The effect of laundry wastes on the operation of a small Imhoff tank, trickling filter plant at Oaklyn, New Jersey, was described by Mr. I. R. Riker, Senior Sanitary Engineer of the New Jersey State Department of Health, at the 1927 meeting of the New Jersey Sewage Works Association. It is printed on pages 17–22 of the 1927 *Proceedings*. The laundry wastes interfered so seriously with the operation of the treatment works that they were disconnected from the sewer system. Analyses are given of the sewage and effluents, with and without the laundry wastes.

Editorial

The New Journal

The first reaction of many to THIS JOURNAL will be "Another journal! We have too many now."

This is the natural feeling of those who desire to keep up with the literature on sewage research and sewage treatment, and who find that it cannot be done unless one joins several societies, subscribes to half a dozen periodicals, and attends two or three national meetings every year. Much less can the average sewage works operator join all the societies and read all the journals.

A first-class man in sewage research and sewage works operation must be rather versatile. He should be well-informed in three sciences, namely, bacteriology, chemistry, and engineering. It is necessary for the student or operator to cull out valuable information from publications in all three branches of his work.

Such necessity has been the mother of this infant journal. The foremost thought in its establishment has been to serve the operators of small sewage treatment works; the second desire has been to give the research workers a more available and distinctive outlet for the reports of their work; a third need has been the establishment of a tie to bind together the various state and local sewage works associations which are developing so rapidly throughout the United States, as evidenced by the proceedings of twelve such groups published in this issue.

The birth of THIS JOURNAL has been not free from effort. Many plans were considered and rejected before the Chemical Foundation came to the rescue and assured its publication. Good fortune has fallen to its lot in gaining the support of this great organization, which stands back of research in America.

The readers of THIS JOURNAL will determine its policy and its future, for the Constitution places its control in the hands of a committee selected by the Board of Control, on which every local or state group has representation. The policy of the Journal will be determined by this committee, as to the relative emphasis and space to be given to research, sewage works operation, proceedings, and abstracts.

The permanent and ultimate fate of the Journal will depend on the rate of increase of its subscribers and advertisers. Supplies and equipment for sewage works are now obtainable from far more concerns than were in the market ten years ago. The growing field of supply men will un-

doubtedly augment the number of advertisers and eventually put the Journal on a self-sustaining basis.

As to the editorial policy, the Editor is particularly sympathetic to the needs of the operator for short, practical, helpful articles on sewage works operation. The ultimate goal of engineers, research workers, and operators is to make it possible to design and operate a sewage treatment plant to the limit of efficiency of the selected process, without forced shutdowns, odors, or complaints. The lamentable neglect and poor operation of small treatment works is partly caused by the inability to bring to the operator a realization of his responsibilities, and the necessity for considering the sewage works as a biological factory which requires constant attention and supervision. THIS JOURNAL will attempt to bring to the operator in a practical way the fruits of research, the experiences of his fellow workmen in meeting and solving difficulties, and news of what is being done in other countries to advance the science of sewage treatment.

Chlorine and Sewage Odors

Evidence is accumulating to indicate that the use of chlorine is quite helpful for elimination of odors from sewage and sewage treatment works. This issue contains papers which describe successful use of chlorine for odor control in Texas, California, and Bath, England. Similar results have been reported from New Jersey, Kansas, Ohio, and Schenectady, New York. For several years chlorine has been used at Leipsic, Germany, for control of odors from sewage at the treatment works and from the Luppe and Elster Rivers below the city.

This simple means for control of odors will be of great value for many sewage treatment works now suffering from the plague of odors. Nothing condemns sewage treatment works so quickly for the average citizen as putrefactive odors, even though localized, and not intense enough to be classed as a public nuisance. The courts have frequently recognized the liability of cities for damages to adjoining property by odors from sewage works. A recent decision against the city of Marceline, Missouri, is quoted in *U. S. Public Health Reports*, **43**, 2115, for August tenth, 1928.

Sluggish flow of strong sewage, high in sulphates, through large combined sewers practically always results in hydrogen sulphide formation, accompanied by obnoxious odors, and in some cases, by sewer disintegration by the oxidation of hydrogen sulphide to sulphuric acid. Chlorine applied at the source of such sewers will, in many cases, retard decomposition sufficiently to prevent odors. An interesting investigation of the chlori-

nation of sewage to prevent sewer corrosion is now under way at the Orange County Outfall Sewer, Santa Ana, California.

Apparently the only problems in this development are those of cost, and the effect of partial sterilization on processes of sewage treatment. If, in all cases, it were necessary to apply chlorine until residual chlorine is present the procedure would be prohibitively expensive. Fortunately experience indicates that partial saturation with chlorine may be sufficient, in most instances, to prevent odors, and yet not harmful to biological processes of sewage treatment.

Not long ago we received a letter from a French chemist stationed at a packing-house in Australia. He wrote "I am told that the Chicago population prefers the smell of abattoirs to the salubrious emanation of chlorine." Apparently he had proposed chlorination for the Australian packing-house wastes, which proposal, he said, led his opponents to "some diabolical statements."

This is the most ardent advocacy of the use of chlorine that has come to our attention.

Sludge Disposal

It appears to be possible to accelerate the digestion of sewage sludge by regulation of temperature and reaction. The collection of gas from decomposing sewage sludge is not new, but the use of this gas for the purpose of maintaining the temperature of sludge at eighty degrees Fahrenheit in separate digestion tanks is a promising development. Extensive research in recent years has led to better knowledge of the processes of biological decomposition of sewage sludge. A few full-scale plants have been installed for the collection of gas and heating of sludge. The data of operation of these plants indicate that the biological principles established by laboratory experiments apply to sludge digestion on a large scale. Well-digested sludge can be obtained in less than two months storage in heated tanks, whereas the same action may require from three to six months in unheated tanks in winter. It therefore appears to be possible to reduce materially the volume of digestion tanks, with consequent economy in construction costs.

The question then arises—What is to be done with the digested sludge at the end of the two months period of storage? Our American winters will not permit outdoor drying from November through March, a stretch of five months. The economy gained by building smaller tanks and heating the sludge is therefore largely fictitious unless the sludge can be removed and dried in winter.

Some engineers propose to solve the problem by designing glass-covered,

heated sludge beds. Others are considering the use of auxiliary storage tanks or lagoons, which can be built more cheaply than digestion tanks. The digested sludge is to be stored in these tanks throughout the winter and dried on open sand beds in summer. A third possibility is the use of vacuum filters or filter presses, which can be operated throughout the winter.

The cost of glass-covered beds is several times as much as open beds; it is questionable whether they will ever be practical for very large plants employing mechanical removal of sludge from drying beds. The use of auxiliary lagoons may accomplish some reduction in cost of plant, but at the expense of operating difficulties. Mechanical sludge filtration is clearly too expensive with present equipment and rates of filtration.

These difficulties have been noted in order to draw attention to the fact that drying of sludge in winter must be made possible at a reasonable cost if we are to enjoy the full benefits of accelerated sludge digestion. The need warrants intensive study.

An Outlaw Organism

The presence of mash residues from home-brew in grit chambers is familiar to most sewage-works operators, but not many have had to contend with the soluble and insoluble remains of "white mule" in quantities such as were received last year at the Des Plaines River Sewage Treatment Works. The normal, hard-working, aerobic bacteria of the activated sludge tanks were completely routed by the hard-boiled, alcohol-soaked organisms whose pictures appear in this issue. With this identification in the rogues' gallery it is to be hoped that the outlaw organisms may be recognized elsewhere before they do much harm. Unfortunately mild and lawful milk wastes may breed the same bugs. We can't very well have a law against bottling milk, but a clever chemist concentrating on hydrogen ions, dextrose and lactose should be able to differentiate the lawful from the unlawful wastes.

Proceedings of Local Associations

Condensed Minutes of Most Recent Meeting of State and District Sewage Works Associations

I. New Jersey Sewage Works Association
Thirteenth Annual Meeting
Trenton, March 23-24, 1928

The New Jersey Sewage Works Association, in coöperation with the State Department of Health, held its Thirteenth Annual Meeting, March 23 and 24, 1928, at the Stacy-Trent Hotel in Trenton. Approximately 150 were present. The features of the meeting were the exhibits of sewage works equipment and the general round-table discussions of topics pertaining to sewage works operation.

The following papers were presented:

1. "The Value of Improving the Appearance of Disposal Works."
   (*a*) J. F. Skinner, Deputy City Engineer, Rochester, N. Y.
   (*b*) E. F. Schissler, Superintendent of Sewers, Haddonfield, N. J.
2. "Odor Investigation of a Sewage Disposal Plant at Haddonfield, New Jersey."
   Leroy Forman, Senior Chemist, New Jersey State Department of Health.
3. "Odor Control by the Use of Chlorine."
   W. J. O'Connell, Jr., New Jersey Sewage Experiment Station.
4. "Odor Control by Covering Plant."
   Chas. Capen, Sanitary Engineer.
5. "Some Causes of Odors."
   Wm. Rudolfs, Chief, New Jersey Sewage Experiment Station.
6. "One Year's Experience with the Trenton Imhoff Tanks."
   P. N. Daniels, City Sanitary Engineer, Trenton.
7. "Initial Operation of Imhoff Tanks at Newcastle, Pennsylvania."
   Wellington Donaldson, Fuller & McClintock, New York.
8. "Pumping Installations of the Hackensack Sewage Treatment Works."
   William Kanngiser, Superintendent of Treatment Works, Hackensack.
9. "Suggestion for Improving Methods of Operation Based on Sewage Experiment Station Work."
   Wm. Rudolfs, Chief, New Jersey Sewage Experiment Station.

In addition to these papers there were round-table discussions of sewage treatment problems led by C. M. Nichols of the Sanitary Engineering Bureau of the State Department of Health and by Dr. Rudolfs. There was also a conference of chemists on methods of determination of biochemical oxygen demand, led by Leroy Forman, Senior Chemist of the Engineering Bureau of the State Department of Health.

Abstracts of the papers and discussions are given in the April, 1928, issue of *Public Works*, and in an abbreviated news note in the March 29, 1928, issue of *Engineering News-Record*. The complete papers have recently been published by the New Jersey Association.

The President of the association for 1928 is Edward Schissler, Haddon Heights. John R. Downes, of the Plainfield Joint District, with offices at Bound Brook, was re-elected Secretary.

II. Texas Water and Sewage Works School
Tenth Annual Meeting
Houston, January 23-27, 1928

The Tenth Annual Meeting of the Texas Water and Sewage Works School was held January 23 to 27, 1928, at the Lamar Hotel in Houston. Demonstrations of laboratory methods were held at the City Health Department Laboratory.

There were 285 registrations. Papers were presented on laboratory methods, water purification, and sewage treatment. Inspection trips were made to the North Side and South Side activated sludge plants, water and sewage pumping stations, Rice Institute and plants manufacturing water and sewage equipment. The social events included luncheons, a theatre party, and a boat ride down the ship channel to San Jacinto.

The retiring officers were:

W. S. Mahlie, *President*, Fort Worth
Dr. A. H. Flickwir, *First Vice-President*, Houston
J. Bryan Miller, *Second Vice-President*, Bryan
O. M. Bakke, *Third Vice-President*, Galveston
J. W. Cunningham, *Fourth Vice-President*, Calallen
V. M. Ehlers, *Secretary*, Austin
E. G. Eggert, *Treasurer*, Austin
Ella G. White, *Editor*, Austin

The new (1928) officers, elected unanimously, are:

J. Z. Martin, *President*, Breckenridge
W. H. Deaton, *First Vice-President*, Waco
Bud A. Randolph, *Second Vice-President*, Houston
L. A. Grimes, *Third Vice-President*, Abilene
J. R. John, *Fourth Vice-President*, Dallas
V. M. Ehlers, *Secretary*, Austin
E. G. Eggert, *Treasurer*, Austin
Ella G. White, *Editor*, Austin

A special conference on sewage research was held on Wednesday evening, January 25th. Professor F. E. Giesecke, Director, Texas Engineering Experiment Station, A. & M. College, outlined the program to be undertaken at College, stating that the work would be confined to fundamentals

in the laboratory and at the local sewage disposal plants. Counsel and advice are to be given by Dr. Willem Rudolfs and the State Health Officer, State Sanitary Engineer V. M. Ehlers, together with coöperation from the Divisions of Sanitary Engineering, Chemistry, and Biology of Texas A. & M. College. Funds for beginning this work are provided in the budget of the Engineering Experiment Station and supplemented by an allotment of $1500 from the Chemical Foundation, Inc., which was made possible by W. W. Buffum, General Manager. After four days of lecture and laboratory work in the respective sections as scheduled, the business session was called to order on Friday morning, January 25th, by the President, W. S. Mahlie, and the regular order of business followed.

The annual membership dues starting with 1928 were reduced to $5.00 for active membership, including subscription to the Journal. Of this, $1.00 is to be remitted to the Treasurer of the Texas Section.

Special Committee: Recommendations were submitted by E. P. Schoch, W. S. Mahlie, V. M. Ehlers, F. E. Giesecke, and W. A. Riney for a plan to assist in the formation of a national society for sewage works operators. The recommendations were unanimously adopted and are as follows:

1. That all members of this Association who are desirous of studying sewage questions be organized into a separate division to be known as the Sewage Division of the Texas Section S. W. W. A.

2. That this Division as a separate unit affiliate with the national organization as suggested by C. A. Emerson, Jr., of the National Committee, and endorse the program to constitute a national organization under the following conditions:

(*a*) That the Texas Division print those papers which are primarily of local or Texas interest, and send abstracts thereof to be printed in the national publication.

(*b*) That papers of national and international interest be selected by the editors for the Texas Division and the National Division to be printed in the national publication.

(*c*) That portions of dues for the national organization are to be paid to the latter for members in the Sewage Division only who are in return to receive the publication of the national organization

3. In the event that the constitution of the S. W. W. A. conflicts in any manner with the establishment of this Sewage Division in the Texas Section as above outlined, it is understood that this Sewage Division automatically becomes a separate and independent organization affiliated with the Texas Water Works Short School or the Texas Association of Sanitarians and proceed with the work through a special committee pending further organization at the next meeting of the Water Works Short School.

The President and the Executive Committee were instructed to report at the next annual meeting upon the advisability of affiliating with the American Water Works Association. A committee was instructed to report on the question of combining with the Texas Association of Sanitarians.

It was voted to hold the 1929 meeting at the A. and M. College and the City of Bryan.

[*Editor's Note.*—The twenty-two papers presented on sewage topics are abstracted beginning on page 106 of THIS JOURNAL.

The Texas representatives on the Board of Control of the Federation are V. M. Ehlers, State Department of Health, Austin, and W. S. Mahlie, Water and Sewage Department, City of Fort Worth.]

III. Ninth Iowa Conference on Sewage Treatment
Iowa State College, Ames, Iowa
November 8, 9, 10, 1927

The Ninth Iowa Conference on Sewage Treatment was held at Ames, Iowa, on Nov. 8, 9, and 10, 1927, under the auspices of the Engineering Extension Department of Iowa State College. Eighty-six municipal officials, operators, and engineers were in attendance.

The program of the Conference consisted of lectures, demonstrations, and round-table discussions of the every-day problems incurred in the care and operation of sewage treatment plants. The following topics were discussed:

The relation of sewage purification to the health of the community.
Sewage treatment conditions in Iowa.
The sanitary laws of Iowa (laws governing local improvements).
Why bacterial action is necessary in treatment tanks and sewage filters.
Construction and principles of operation of septic tanks.
Difficulties in the operation of septic tanks.
Imhoff tanks—their design and principles of operation.
When should grit chambers and sewage screens be used?
Separate sludge digestion.
Chemical treatment of sewage.
Sludge removal and disposal.
Difficulties with sand filters.
The construction and operation of sprinkling filters.
Getting a plant into shape for winter operation.
The requirements of successful sewage treatment plant operation.
Why bother with sewage plant records?
Making the sewage treatment plant attractive.
The sewage treatment plant operator's job.
Plant control tests.
Laboratory work.
Treating creamery wastes.
Beet sugar and cannery waste disposal
The toxic effect of industrial waste (Newton).
The status of stream pollution.

During the Conference a session was held at which the organization of a State Sewage Works Association was discussed. Committees were appointed which drafted a constitution and nominated officers. The Iowa Wastes Disposal Association was officially organized and officers elected

on November 10th. Authorization was given for a representative to participate in conferences to be held at a somewhat later date looking toward the organization of a National Sewage Works Association.

The Secretary of the Conference is Mr. Lindon J. Murphy, Municipal Engineer, Ames, Iowa. The Iowa representatives on the Board of Control of the Federation are:

Dr. Max Levine, Dept. of Bacteriology, Iowa State College, Ames
Jack J. Hinman, University of Iowa, Iowa City.

IV. North Carolina Water Purification and Sewage Treatment Conference
Fifth Annual Conference
Durham and Chapel Hill, Nov. 7-9, 1927

The Fifth Annual Conference of the North Carolina Water Purification and Sewage Treatment Conference was held in Durham and at the University of North Carolina on Nov. 7-9, 1927. This was a joint meeting with the Seventh Annual Convention of the North Carolina Section of the American Water Works Association. An attendance of 260 was recorded. Papers were presented on water purification, sewage disposal, and stream pollution.

Special excursions and social affairs included a 30-mile automobile trip to the new water filtration plant of the City of Durham; a barbecue in the new hydro-electric plant; motion pictures of water works construction in North Carolina; a visit to the University's water purification plant and laboratories of sanitary engineering; and the annual association banquet.

Papers on sewage disposal and stream pollution were presented by W. L. Stevenson, F. H. Waring, A. O. True, C. W. Smedburg, H. P. Sparmaker, Geo. D. Norcom, L. H. Enslow, and J. T. Thresher. These papers as well as those on water purification have been printed in a 200-page volume published by the State Department of Health and the Publication Committee, E. G. McConnell and W. E. Vest, Charlotte, N. C.

The officers elected for 1928–29 were:

J. S. Whitener, *President*, Raleigh
G. F. Catlett, *Secretary*, Raleigh

The Secretary-Treasurer of the North Carolina Section of the A. W. W. A. is H. G. Baity of Chapel Hill.

The Section expressed itself as being favorable to the policy of continuing the discussion of sewage treatment and stream pollution subjects in the program of the annual conventions, and considered this year's experiment a great success. The matter of joining the National Federation for the publication of sewage papers was discussed at length, the Section

expressing itself as favorable to the plan and authorizing the Executive Committee to take the proper action to effect such affiliation.

[*Editor's Note.*—In June, 1928, the Executive Committee voted to join the National Federation, and appointed the following representatives for the Board of Control, to serve until the annual meeting (North Carolina) in November, 1928:

H. E. Miller, Chief Engineer, State Dept. of Health, Raleigh.

W. M. Piatt, Consulting Engineer, Durham.]

It was voted to hold the 1928 Convention on Nov. 5–7 at Raleigh.

The papers on sewage subjects printed in Volume 5, No. 1, were as follows:

1. "Why Sewage Treatment?" F. H. Waring, Chief Engineer, Ohio State Department of Health.
2. "Waterway Sanitation," W. L. Stevenson, Chief Engineer, Pennsylvania State Department of Health.
3. "Disposal of Industrial Sewage," A. O. True, Sanitary Engineer, Proximity Mfg. Co., Greensboro, N. C.
4. "Sewage Treatment Financing in Ohio," F. H. Waring.
5. "Sewage Treatment Plants and Devices," C. W. Smedburg, Superintendent, Water Department, Greensboro, N. C.
6. "Imhoff Tanks," H. P. Sparmaker, New Jersey State Department of Health.
7. "Separate Sludge Digestion," George D. Norcom, Superintendent of Filtration, Charlotte.
8. "Correcting Odor Nuisances," L. H. Enslow, Research Engineer, The Chlorine Institute.
9. "Direct-Oxidation Works at Winston-Salem," J. T. Thresher, Department of Public Works, Winston-Salem.
10. "Sewage Filters," F. H. Waring.

V. Pennsylvania Conference of Sewage Works Operators
Third Annual Conference
State College, Pennsylvania, July 10-11, 1928

The Third Annual Meeting of the Pennsylvania Sewage Works Association was called to order by President Elton D. Walker at 10 a.m., July 10, 1928, in one of the engineering buildings of the Pennsylvania State College at State College. Sixty-seven men registered and remained throughout the program, which occupied two days. In addition to the papers listed on the program there was a round-table discussion of operator's problems Tuesday evening.

A forty mile automobile excursion was made through the mountains to inspect the Alvord-tank type of sewage treatment works at Laurelton State Village.

The Association voted unanimously to affiliate with the Federation of Sewage Works Associations. It is represented on the Board of Control by C. A. Emerson, Chairman, and H. E. Moses, Secretary-Treasurer, of the Federation. Mr. J. R. Hoffert, Harrisburg, was appointed local editor

to coöperate with the national editor of the Journal concerning publication of papers of the Pennsylvania meeting.

The following papers were presented:

1. "Modern Sewage Treatment from the Operator's Standpoint," E. B. Besselievre, The Dorr Company, New York.
2. "Some Features of the Separate Sludge Digestion Plants at Butler and Sharon," Philip S. Wickerham, Consulting Engineer, Sharon, Pa.
3. "Results of Operation at Sharon," Lewis E. Burnside, City Engineer, Sharon.
4. "Operation of Imhoff Tanks," H. M. Beaumont, Bureau of Engineering, Philadelphia.
5. "Sludge and Sludge Disposal," C. A. Emerson, Fuller and McClintock, Philadelphia.
6. "Operation of Trickling Filters," E. Sherman Chase, Metcalf and Eddy, Boston.
7. "Value and Use of Routine Tests in Sewage Plant Operation," H. M. Freeburn, Pennsylvania State Department of Health, Philadelphia.
8. "The Alvord Tank," J. R. Hoffert, Civil Engineer, The Sanitary Water Board, Harrisburg.

Officers elected for the coming year are:

H. E. Moses, *President*, Harrisburg
L. E. Burnside, *First Vice-President*, Sharon
H. M. Beaumont, *Second Vice-President*, Philadelphia
R. O'Donnell, *Secretary-Treasurer*, State College

VI. Kansas Water Works Association and Short School
Third Annual Meeting
Lawrence, Feb. 14-16, 1928

The Third Annual Meeting of the Kansas Water Works Association and the Sixth Annual "Three Day School" was held Feb. 14–16, 1928, at Lawrence. Approximately twenty-five papers were presented, of which only three pertained to sewage disposal. These papers were:

"Control of Sewage Disposal Plant Odors," R. E. Lawrence, Asst. Engineer, State Board of Health.

Discussion, Glen Hackmaster, City Engineer, Independence.

"The Role of Bacteria in Sewage Disposal," Max Levine, Iowa State College, Ames, Iowa.

"Recent Developments in Separate Sludge Digestion," Wayne A. Kivell, The Dorr Company, Chicago.

The first of these papers has been published as a bulletin by the Kansas State Department of Health, under the supervision of Earnest Boyce, Director of the Division of Water and Sewage, Lawrence, Kansas.

VII. Missouri Conference on Water Purification
Third Annual Meeting
Sedalia, October 13-15, 1927

The Third Annual Meeting of the Missouri Conference on Water Purification was held Oct. 13–15, 1927, at Sedalia. There were 52 members

and 25 associate members present. Fourteen papers were presented on water subjects and five on sewage subjects. These five were:

1. "Separate Sludge Digestion," George S. Russell, Consulting Engineer, Springfield.
2. "The Economic Side of Sewage Disposal," N. T. Veatch, Consulting Engineer, Kansas City.
3. "Disposal of Sewage in Small Inland Towns," T. L. Wiley, President, Board of Public Works, Cameron.
4. "Correcting Odor Nuisances at Sewage Plants by Chlorination," L. H. Enslow, The Chlorine Institute.
5. "Modern Methods of Sewage Treatment," Dean E. J. McCaustland, College of Engineering, University of Missouri, Columbia.

Inspection trips were made to the Sedalia water purification and sewage treatment plants.

The following officers were elected for 1928:

Dr. A. C. Magill, *Chairman*, Cape Girardeau
C. E. Heflin, *Vice-Chairman*, Cameron
H. D. Peters, *Secretary-Treasurer*, Jefferson

W. Scott Johnson, Chief Sanitary Engineer of the State Department of Health, is Corresponding Secretary since his return.

[*Editor's Note.*—A recent letter from Mr. Johnson states that it is the intention of the Missouri Conference to change the name to "Missouri Conference on Water Purification and Sewage Treatment." He also states that the officers and executive committee are unanimously in favor of affiliating with the Federation of Sewage Works Associations and that they feel assured that this affiliation will be completed at the time of the next meeting in the fall of this year.]

VIII. Maryland Water and Sewerage Association
Second Annual Conference
Baltimore, April 10-11, 1928

The Second Annual Conference of the Maryland Water and Sewerage Association was held April 10-11, 1928, at Baltimore. An attendance of 163 was recorded. The first day was devoted to papers and discussions on water and sewage problems. During the morning of the second day papers on sewage and industrial waste treatment and swimming pool sanitation were delivered. The afternoon was spent in making an inspection of the Towson sewage treatment works and of one of Baltimore's refuse incinerators.

One of the most interesting features of the meeting was the dinner and round-table discussion held on the evening of the first day, at which approximately 115 were in attendance. No assigned speakers were on this program, but considerable interest was shown in the discussion of the questions presented by the association members.

The opening meeting was called to order by Abel Wolman, the President,

who introduced Dr. R. H. Riley, Assistant Director of the State Department of Health. Dr. Riley discussed the benefits derived from this meeting of the local association and urged a continuation of the coöperation shown by the water and sewage works operators, with the ultimate object of reducing disease, especially through the elimination of typhoid fever.

The following four papers were presented, dealing with sewage and industrial wastes:

1. "Sewer Maintenance," by W. J. Ruark. Mr. Ruark considered maintenance due to depreciation, the misuse of sewers, the disposal of snow, oil, and gasoline. He pointed out the essential features of some of the cleaning tools and gave cost data for maintenance during 1927 of Baltimore sewers.

2. "The Sewage Treatment Works at Gaithersburg" was presented by H. R. Hall. This plant is the usual sprinkling filter type with sedimentation before and after the sprinkling process, together with separate digestion.

3. "Treatment of Laundry Wastes," L. E. Sakers and F. M. Zimmerman, printed in THIS JOURNAL.

4. "Comments on Methods for Determination of Residual Chlorine," Linn H. Enslow, Printed in THIS JOURNAL.

The officers elected for 1928 are:

President, E. H. Dryden, Chief Engineer, Salisbury Water and Sewer Commission.

First Vice-President, C. A. Hechmer, Department Engineer, Washington Suburban Sanitary District.

Second Vice-President, Albert Heard, Superintendent, Hagerstown Water Board.

Treasurer, Edward S. Hopkins, Sanitary Chemist, Baltimore City Water Department.

Secretary, T. C. Schaetzle, Senior Asst. Sanitary Engineer, Maryland State Department of Health.

[*Editor's Note.*—A meeting of the Executive Committee of the Maryland Association has been held since the 1928 Annual Meeting. It was voted unanimously that the Maryland Association join the National Federation of Sewage Works Associations. Abel Wolman and F. H. Dryden were elected to serve on the Board of Control of the Federation.]

IX. Ohio Conference on Sewage Treatment
First Annual Conference
Cleveland, October 26, 1927

The First Annual Conference of the Ohio Sewage Works Association was held October 26, 1927, at the Hotel Winton in Cleveland. The meeting preceded by one day the Seventh Annual Conference on Water Purification.

There were 45 in attendance. A general discussion was held at noon and following a dinner in the evening a brief business session was held. The afternoon was spent in a visit to the new Southerly Sewage Treat-

ment Works, which was described in a brief talk given by George B. Gascoigne, in charge of its design and construction.

The meeting was called to order by F. H. Waring, Chief Engineer of the Ohio State Department of Health, who acted as temporary chairman. He stated that the meeting was essentially an organization meeting, called at the instance of the State Department of Health, in response to numerous expressions of interest in such an organization and the conviction that an opportunity for sewage works operators of Ohio to meet for discussion of mutual problems was of prime importance.

A constitution was adopted at the evening meeting and officers elected as follows:

C. D. McGuire, *Chairman*, Columbus
Floyd G. Browne, *Vice-Chairman*, Marion
F. W. Jones, *Secretary-Treasurer*, Cleveland
L. T. Fawcett, *Member of Executive Committee*, Youngstown
F. D. Stewart, *Editor*, State Department of Health, Columbus

Marion was tentatively selected as the 1928 meeting place.

Mr. Stewart has published the minutes of the meeting, a list of those present, the constitution, and two papers as appendices in a 29-page booklet. Appendix I is a description of the Southerly Sewage Treatment Works by George B. Gascoigne. Appendix II is a discussion by Mr. Waring of experiences in Ohio in financing sewage treatment operation. Attached to Mr. Waring's paper are six exhibits, which include the well-known Ohio sewer rental law, a classified list of sewage treatment works in Ohio, and several examples of model sewer rental ordinances adopted by several cities and villages.

X. Central States Sewage Works Association
First Annual Meeting
Milwaukee, May 25-26, 1928

A preliminary meeting of seventeen chemists and engineers interested in the operation of sewage treatment works was held December 17, 1927, at the University Club of Chicago. Those present represented the states of Illinois, Indiana, and Wisconsin. Following a complimentary luncheon by Paul Hansen, ways and means were discussed for launching a local organization for those identified with the operation, design, construction, and management of sewage works.

It was voted unanimously to proceed with the organization of the Central States Sewage Works Association. A constitution was adopted—proposed by Langdon Pearse and amended in some details.

Officers were then elected as follows:

Robert Cramer, *President*, Milwaukee, Wisconsin
Lewis S. Finch, *First Vice-President*, Indianapolis, Indiana

F. W. Mohlman, *Second Vice-President*, Chicago, Illinois
G. H. Radebaugh, *Secretary*, Urbana, Illinois
L. F. Warrick, *Treasurer*, Madison, Wisconsin

President Cramer, on taking the chair, appointed Langdon Pearse a delegate to represent the newly-formed organization at the meeting of the American Society of Civil Engineers in New York in January, 1928, in order to take part in the discussion of the formation of the National Federation of Sewage Works Associations.

It was suggested that the first annual meeting be held in Milwaukee. President Cramer called this meeting for May 25 and 26, 1928, in conjunction with the 1928 meeting of the League of Wisconsin Municipalities.

The First Annual Meeting was attended by 46 persons, mostly from Wisconsin. President Cramer outlined the reasons for the formation of the association, its purposes and aims. Mr. Warrick, Treasurer, in the absence of Mr. Radebaugh, Secretary, briefly reviewed the business of the preliminary meeting in Chicago. The matter of the publication of the Federation Journal was brought up by Mr. Warrick and discussed by Dr. Rudolfs and others. It was voted that the association was in favor of accepting the offer of the Chemical Foundation to guarantee the publication of the Journal.

The Treasurer's report was read and approved.

The most interesting features of the meeting were: a banquet at the Milwaukee Athletic Club on Friday evening; a visit to the activated sludge plant on Jones Island Friday afternoon; and a round-table discussion with practical demonstration of laboratory control tests at the plant on Jones Island Saturday afternoon.

The papers presented were as follows:

1. "Chicago's Sewage Treatment Program," Langdon Pearse, Sanitary Engineer, The Sanitary District of Chicago. Read by S. L. Tolman.
2. "Aims of the Central States Sewage Works Association," Adolph Kanneberg, Chairman, Wisconsin Water Pollution Committee; L. F. Warrick, Chief Engineer, Wisconsin Dept. of Health. Printed in THIS JOURNAL, page 9.
3. "Separate Sludge Digestion in Wisconsin," Jerry Donohue, Sheboygan.
   Discussion by Dr. Wm. Rudolfs, New Jersey Sewage Experiment Station, and Frank Quimby, City Engineer, Antigo, Wisconsin.
4. "Sewage Treatment for Small Municipalities," Walter A. Pierce, Consulting Engineer, Madison.
   Discussion by O. T. Muegge, Wisconsin State Department of Health.

In addition to these papers reports were read and adopted as presented by committees on Financing Municipal Sewage Treatment and Sewage Plant Control Tests.

The First Annual Meeting was adjourned after the round table-discussion at Jones Island Saturday afternoon.

[*Editor's Note.*—The Constitution of the Central States Association states that the annual dues shall be $5.00, of which the Officers are authorized to pay not to exceed $3.00 annually to the National Federation. Inasmuch as the National Federation requires only $1.00 per member and $5.00 per year is more than the annual dues of most of the local and state sewage works associations, it has been proposed that the dues be reduced to $3.00 per year. This proposal is now under consideration.

President Cramer has appointed the following men to represent the Central States Association on the Board of Control of the National Federation:

L. F. Warrick, State Sanitary Engineer, Madison, Wisconsin.

Lewis S. Finch, State Sanitary Engineer, Indianapolis, Indiana.]

XI. California Sewage Works Association Organization Meeting San Francisco, June 11, 1928

An organization meeting of those interested in the operation and management of sewage treatment works in California was called May 2, 1928, by State Sanitary Engineer C. G. Gillespie. The meeting was held June 11, 1928, at the State Building, San Francisco. Fifty-one were present including George W. Fuller and Wellington Donaldson of New York City, Abel Wolman of Baltimore, and E. G. Eggert of Austin, Texas.

Mr. Gillespie called the meeting to order and described the purposes and aims of the contemplated local association and the national federation. He stated that the local meetings would enable operators, city engineers, councilmen, consulting engineers, and others to compare operating experiences, enter into round-table discussions, and make inspection trips which would be of decided personal value and at the same time make for improved operation and management of California's sewage treatment works.

Those present were unanimously in favor of the formation of such an association.

Mr. George W. Fuller then discussed the formation of the Federation of Sewage Works Associations and the publication of the quarterly Journal.

Mr. Wolman described the 1928 Maryland meeting and Mr. Eggert the Texas meeting, stating that both groups had applied for membership in the Federation.

It was voted unanimously that the California Sewage Works Association should apply for membership in the Federation. The following organization committee was appointed:

A. K. Warren, *Chairman*, 202 Law Building, Los Angeles
Andrew M. Jensen, City Hall, Fresno
O. E. Steward, City Hall, Anaheim
Philip Schuyler, 114 Sansone St., San Francisco
C. G. Gillespie, 102 Civil Engineering Building, Berkeley

After considerable discussion it was voted that the annual dues should be two dollars, without admission fee, of which one dollar is to be sent to the Federation for membership and subscription to the Journal.

The organization committee, by letter ballot at a later date, appointed the following men as representatives of the California Association on the Board of Control of the Federation:

W. T. Knowlton, City Hall, Los Angeles

Clyde C. Kennedy, Call Building, San Francisco

The First Annual Meeting will be held October 8, 1928, at San Bernardino, in conjuction with the meeting of the League of California Municipalities.

XII. Arizona Public Health and Sanitary Conference
First Annual Meeting
Tucson, April 17-18, 1928

The First Annual Arizona Conference on Public Health and Sanitation was held April 17–18, 1928 at Tucson. The program included papers on milk and water supply, and sewage disposal. The afternoon of June 17th was devoted to the presentation of five papers on sewage treatment followed by a trip to the Tucson sewage farm and disposal plant.

The papers on sewage disposal were as follows:

1. "Activated Sludge Plant at Grand Canyon," M. R. Tillotson, Superintendent, Grand Canyon National Park.

Discussion by V. M. Ehlers, Austin, Texas.

2. "Use of Chlorine in Sewage Treatment," A. L. Frick, Field Engineer, Wallace and Tiernan Company.

3. "Sewage Treatment Plants for Small Cities," Chester A. Smith, Burns and McDonnell, Los Angeles.

4. "The New Sewage Disposal Plant at Tucson," George Grove, City Engineer, Tucson.

Discussion by F. M. Veatch, Kansas City and A. M. Kivari, The Dorr Company.

5. "Broad Irrigation with Sewage," G. E. P. Smith, Irrigation Engineer, University of Arizona, Tucson.

The papers are to be published in the July issue of the Quarterly Bulletin of the Arizona State Board of Health.

There were eighty-five men and women in attendance. Informal luncheons were held each day at the University Commons. The formation of a sewage works association was discussed as a subsidiary of the Public Health Conference. Miss Jane H. Rider, Director of the State Laboratory, was elected to represent the association in the National Federation.

Proceedings of Other Associations

Other state and local associations have been formed but the proceedings are not available for this issue of the Journal. Meetings have been held in Michigan, Colorado, Oklahoma, and possibly other states where papers have been presented and discussions held on the subjects of sewage treatment and stream pollution. The proceedings of some, if not all, of these meetings will be published in future issues of THIS JOURNAL.

Reviews and Abstracts

A Review of American Literature on Sewage Treatment and Stream Pollution

F. W. MOHLMAN[1]

Chapter from "Annual Survey of American Chemistry, July 1927–June, 1928"[2]

Several excellent books have been published during the past year on sewage treatment including Buswell's "The Chemistry of Water and Sewage Treatment" (The Chemical Catalog Company, New York); Martin's "The Activated Sludge Process" (MacDonold and Evans, London) which, although written by an English author, is a fairly up-to-date review of American work; "The Newer Knowledge of Bacteriology" (University of Chicago Press) by Jordan and Falk; and several others. Much information of value appears in annual reports or experiment station reports which have a limited circulation.

Research

Sewage research has centered mainly on the oxygen requirements of sewage, the chlorination of sewage and effluents, and the digestion of sewage sludge.

An outstanding monograph on the biochemical oxygen demand determination was issued by Theriault.[1,*] This determination is of extreme importance in problems of sewage treatment and stream pollution, but it has required considerable research to demonstrate that the method could be made reliable and accurate. Theriault gives the details of manipulation, also data on the precision obtainable. He shows that the rate of demand for freshly polluted waters follows the logarithmic course of a first-order reaction during the first stage of decomposition and gives equations for determining the rate and magnitude of the demand. Mohlman, Edwards and Swope[2] conclude that the dilution method is preferable to the nitrate method for biochemical oxygen demand determination, provided care is taken in analytical procedure and a standardized dilution water is used. Distilled water gave low results. Two stages were found in the B. O. D. of sewage, as shown by Theriault, but only one stage with starch waste. Data indicate that the secondary increase in B. O. D. is correlated with an in-

[1] *Chief Chemist, The Sanitary District of Chicago.*

[2] *Published by Chemical Catalog Company; preprinted by permission of the National Research Council.*

* Numbers in text refer to bibliography at end of article.

crease in nitrate. Rates of B. O. D. change as a stream undergoes self-purification. Studies of sewage and effluents in various stages of purifications gave curves similar to those obtained on samples from the Illinois River.

The present status of the chlorination of sewage and effluents has been reviewed by Enslow.[3] Tiedemann[4] reported results of chlorination of Imhoff effluent at Huntington, New York. Residual chlorine of 0.2 p. p. m. by ortho-tolidin with contact periods of 5 minutes gave 99.8 per cent reduction of *Bact. coli*. The chlorine penetrated the solids quite effectively. Chlorine demand varied from 6.5 p. p. m. in February to 12.0 or 13.0 p. p. m. in July and August. Mahlie[5] chlorinated trickling-filter effluent at Fort Worth, Texas. Approximately 3.5 p. p. m. greatly improved the effluent of the secondary sedimentation tanks by retarding septicization. Scott[6] chlorinated screened sewage at Bridgeport and reported that 15 p. p. m. was required. Cohn[7] has made further study of chlorination at Schenectady. Application of 6.0 p. p. m. to the raw sewage reduced odors. Filter flies, *psychoda alternata*, were not eliminated by application of 25 p. p. m. to the filter influent for 24 hours at two-week intervals. Biological films on filter stone were removed by this treatment. Odors have been prevented to some extent at Plainfield, N. J.,[8] by application of 12 p. p. m. chlorine after screening. At Haddonfield 20 p. p. m. was required to give residual chlorine and eliminate H_2S. It was claimed by Hackmaster[9] that application of 3.32 p. p. m. chlorine to the crude sewage of Independence, Kansas, eliminated odors from the Imhoff tanks and trickling filters. Rudolfs and Zeller[10] reported that heavy doses of chlorine to the Plainfield, N. J., filter influent did not eliminate filter flies.

Sludge digestion has been studied at various sewage experiment stations, particularly the New Jersey Sewage Experiment Station, New Brunswick, under the direction of W. Rudolfs. The annual report for 1927[10] gives interesting data on the digestion of sludge in two separate sludge digestion tanks at Plainfield. The sludge was heated to 68° F. and pH adjusted to 7.3 by addition of lime. Good digestion occurred in 40 days but the moisture content of the sludge as drawn was quite high, averaging 92 5 per cent, and the amount of gas collected was quite low, because of leaks in the wooden cover of the tank. Seeding materials for starting new digestion tanks are of decreasing value as follows: ripe sludge, sludge or mud from polluted river bottoms, cow or horse manure.

The beneficial effect of lime on digestion of settled solids was reported by Rudolfs in his 1926 Report. Fair and Carlson[11] used limestone for control and report that the time of digestion for uncontrolled sludge was 24 weeks, that of controlled sludge 8 weeks. Their results indicate that pH of 6.8 is probably the optimum for the first stage of digestion and 7.2 for the final stage. Fair and Carlson[12] also studied the effect of chlorine on sludge

digestion and report that laboratory experiments indicated that Imhoff sludge from Schenectady which had been treated with 10 p. p. m. chlorine leaving a residual of 1.5 p. p. m. digested slightly more rapidly than sludge from an adjacent tank which had not been chlorinated.

The source of the excessive acidity and CO_2 production during the first few weeks of uncontrolled sludge digestion has been of interest. Heukelekian[13] claims that cellulose decomposes quite rapidly and gives results of experiments on Plainfield sludge which indicated that from 80 to 95 per cent of the initial cellulose disappeared in the first three weeks. Approximately 10 per cent of the organic content of the fresh sludge was cellulose. Rudolfs[10] confirms and amplifies these conclusions in his 1927 Annual Report. On the other hand, Neave and Buswell[14] ran digestion experiments with Urbana (Illinois) sludge which showed practically no loss of cellulose in 9 weeks. They claim that grease and lime soaps decompose most rapidly and are responsible for the initial acid stage of sludge digestion. The initial content of grease in the sludge used was 35 per cent of the organic matter, cellulose only 17 per cent. Increasing gas production was found with increasing content of grease.

Heukelekian and Rudolfs[15] claim that nitrogen does not disappear during sludge digestion. Their experiments were carried out to 240 days at 24° C. There was an absolute reduction of carbon but an increase in the per cent of carbon in the volatile matter.

Hatfield[16] found very rapid digestion of Imhoff sludge at Decatur, Ill., where 50 per cent of the sewage flow is waste from a starch plant, which is quite warm and concentrated, and high in sulphates and starch. The gas contained up to 0.95 per cent H_2S, increasing with the temperature of sewage, which varied from 20° to 40° C. throughout the year. Rudolfs[17] and Zeller studied the effect of sea water on sludge digestion and report that the retardation of gas production is slight with as much as 10 gr. per liter of NaCl. Sulphates were almost completely decomposed, mainly to free sulfur. H_2S was found in increasing amounts with increase in sulfates but the maximum H_2S production was only 5.6 per cent of the sulphur originally present in sulfates.

Rudolfs[18] and Fair and Carlson[19] have reported that activated sludge digests quite well when properly seeded, also that control of pH by lime (Rudolfs) and calcium carbonate (Fair) stimulated gas production. Fair and Carlson reported fairly high yields of gas from unseeded activated sludge. Rudolfs concluded that the amount of gas from activated sludge either seeded or unseeded was less than from an equal weight of organic matter in fresh sewage solids, and Imhoff[20] had also reached this conclusion several years earlier. The differences may have been on account of the high temperature of incubation, 37° C., used by Fair as compared with 20° C. used by Imhoff and Rudolfs.

Sewage Works Operation

Activated Sludge.—Cramer[21] has reported on the present status of operation of the Milwaukee activated sludge plant. In January, 1928, it was treating the capacity flow of sewage, 86 million gallons per day, from which 100 tons of dry fertilizer are produced. The cost of operation for pressing and drying sludge is reported to be slightly less than its net selling price. Sulphuric acid, alum, chlorinated copperas and ferric chloride are used for coagulation of sludge and are increasingly efficient in the order named. Chlorine is used for deodorizing the dryer discharge. Kadish[22] states that the sludge sells readily. It averages 5.4 per cent nitrogen and 3.1 per cent phosphoric acid. Wilson and Cramer[22] consider the action of activated sludge to be physico-chemical and not dependent on bacterial action. They claim to have purified sewage in contact with activated sludge by aerating with a mixture of air and chlorine equal to 300 lbs. chlorine per million gallons of sewage.

Palmer and Mohlman[23] describe experiments on coagulants for activated sludge, particularly the discovery of the value of ferric salts, which had not been previously used. Ferric chloride was too expensive but a fairly cheap substitute, although not as effective, was found by chlorinating copperas, giving a mixture of ferric chloride and sulphate.

Activated sludge from the Indianapolis activated sludge plant is digested with settled sludge in large open pits. Calvert[24] claims that it dries to a non-odorous sludge of 85 per cent moisture content which contains 4.5 per cent nitrogen on the dry basis. It is in great demand locally for fertilizer.

Activated sludge plants are now in operation at many American cities, including Milwaukee, Indianapolis, Chicago, Houston, Waco (Texas), Tenafly (N. J.), Mamaroneck (N. Y.), Pasadena and Pomona (Cal.), Gastonia and Charlotte (N. C.), and at numerous smaller cities. The North Side Activated Sludge Plant of the Sanitary District of Chicago will go into operation in 1928. This is the largest plant of its kind in the world and is built to handle 175 million gallons per day. New York is contemplating the construction of a plant of equal size on Ward's Island.

Sludge Digestion

Digestion of settled sludge can be accomplished either in Imhoff tanks, in which the sludge compartment is below the settling compartment, or in separate digestion tanks. The latter are now being built in increasing numbers, mainly because of the possibility of heating the sludge by means of the gas produced by biological decomposition of the organic matter. Fischer[25] has reported tests on the operation of such a plant at Antigo, Wisconsin. The digester has a capacity of 34,000 cu. ft. for 5600 connected population. An average of 0.64 cu. ft. of gas has been recovered per capita per day, all of which has been used to heat the sludge to an average tempera-

ture between 65° and 83° F. The organic solids were reduced to 25 per cent of the initial weight by digestion.

Blew[26] gives operating results for the digestion tanks at Merchantville, New Jersey.

Gas is collected from the new Imhoff tanks at Newcastle, Pa., described by Donaldson.[27] Initial difficulties on account of acid sludge have now been overcome.

Industrial Wastes

Iron pickling wastes have been very detrimental to the operation of the new Imhoff tanks at Worcester, Mass., as reported by Lanphear.[28] The sludge production is excessive on account of the voluminous precipitate of ferrous and ferric hydroxides. The pH of the sewage averages 6.3, with a half-hourly fluctuation from 3.4 to 9.1. Rates of application to trickling filters are quite low because of the acidity and iron content of the settled sewage.

Similar difficulties in sewage treatment because of industrial wastes are reported by Mohlman.[29] Acid wastes from a paint factory containing copper, anilin dyes, sodium sulphite, and lead were quite detrimental to the operation of an activated sludge plant even though diluted 50 or 100 times by a large volume of sewage. The presence of the wastes required doubled tank capacity and tripled air supply. Plans for elimination of wastes are described.

Coburn[30] reports that lime treatment of iron-pickling liquors is too costly and recommends addition of scrap iron to neutralize acidity, with recovery of ferrous sulphate.

Lime treatment of wastes containing acetic and sulphuric acids, calcium sulphate and tarry discharges from ethyl acetate stills is recommended by Snell.[31] Filtration of the lime sludge on an Oliver filter was successful but the final effluent still had 6000 p. p. m. oxygen consumed.

Nelson[32] reports that treatment of packinghouse waste at Mason City, Iowa, by activated sludge has been somewhat unsuccessful on account of overload, very concentrated wastes, and poor operation. Jenks[33] and Levine have reported experiments on the treatment of this waste by repeated circulations of waste and activated sludge in shallow streams over riffled surfaces, their so-called "stream-flow process."

Stream Pollution

An exhaustive report on a study of the pollution and natural purification of the Illinois River was issued during the past year by J. K. Hoskins, C. C. Ruchhoft and L. G. Williams[34] of the U. S. Public Health Service. This report included hydrometric studies and chemical and bacteriological analyses of samples collected daily from Lockport to the mouth of the river, a distance of 290 miles. The report is of general interest because it includes

equations, based on the analytical results, which express the laws of self-purification of polluted waters and the death rates of bacteria as affected by dilution, temperature and time.

Another interesting report, issued in 1927 by H. R. Crohurst and M. V. Veldee[35] of the U. S. Public Health Service, deals with the results of an investigation of the pollution of Lake Michigan off South Chicago and the Calumet District in Indiana. The work covered investigations of the discharge of sewage and industrial wastes into Lake Michigan and the resulting pollution as measured by analyses of 5232 samples collected at 72 sampling stations over a period of 10 months. Only at a distance of from 5 to 8 miles offshore was water found which had a *Bact. coli* index of less than 2 per 100 cc. Variable currents of polluted water could be traced for 15 or 20 miles, driven by winds to the water intakes of Chicago. The course of this distribution is shown by contours of bacterial counts. Sources of pollution were found to be mainly tributary to the Indiana Harbor Ship Canal and directly to the lake at Whiting and Hammond. Sewage treatment and disposal of industrial wastes were strongly recommended.

References

1 *U. S. Public Health Service, Bull.* **173** (1927).
2 *Ind. Eng. Chem.*, **20**, 3 (1928).
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4 *Eng. News-Rec.*, **98**, 23 (1927).
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[30] *Ind. Eng. Chem.*, **20**, 3 (1928).
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A Digest of Papers Presented at the Tenth Texas Water and Sewage Works School,[1] Houston, Texas, Jan. 23 to 27, 1928

ABSTRACTED BY E. HURWITZ

1. The Need of Sewage Research in Texas. Willem Rudolfs. Unsatisfactory results of operation of sewage treatment works are usually due either to limited knowledge of the underlying principles of the processes involved or to environmental difficulties peculiar to each specific installation. Research on basic principles and effect of local conditions is needed in Texas.

2. Design Data for an Activated Sludge Plant. J. C. McVea and S. L. Fugate. Houston is altering and enlarging the North Side Activated Sludge Plant. New features are grit chambers, conversion of hopper bottom settling tanks into aeration tanks, new settling tanks, sludge conditioning equipment and vacuum filter.

3. Filtering Material for Sewage Works—Kinds, Size and Depth. N. T. Veatch, Jr. Crushed stone used for trickling filters should be from $1\frac{1}{2}$ to 2 inches in diameter. Sand for intermittent filters and sludge beds should vary between 0.25 and 0.50 mm. effective size.

4. Mechanical Aeration. M. B. Tark. In England Haworth's paddle wheel, Hartley's spiral flow and the Simplex types of mechanical aerators for the activated sludge process are used with considerable success. Imhoff in the Essen district uses a brushwood aerator in combination with diffused air. In this country the Simplex is the only type of mechanical aerator in practical use.

5. Sewage Dosing Apparatus for Sprinkling Filters. Wynkoop Kiersted, Jr. Inertia and friction losses must be carefully watched in the design of dosing apparatus. Double dosing tanks offer greater flexibility, more even distribution of sewage over the filter, and closer control than single units.

6. Sewer Rentals. U. S. Allison. Of the three methods of raising funds for the financing of sewer systems—(1) by charging rentals, sewer, (2)

[1] The complete papers are published by the State Department of Health, Austin, Texas, in a 294-page volume sold at $1.00 per copy.

by levying a separate tax, (3) from the general fund—the separate tax levy seems to be the most scientific.

7. Mechanical Sedimentation Tanks. George Plews. The design of continuous settling tanks must be such that the velocity through them is less than the critical settling rate of the particles. This critical settling rate of the particles is dependent on the size, shape and density of the particles and the density and temperature of the liquid.

8. Recent Sewage Studies at Houston, Texas. G. L. Fugate and W. S. Stanley. The optimum conditions for filtering activated sludge at Houston are: (1) the sludge must be fresh and well aerated, (2) there must be little agitation after addition of conditioners, (3) pH for best filtering is SO_2, 3.2–3.6; H_2SO_4, 3.4; alum, 4.4–4.8, chlorinated copperas, 5.4 Automatic devices for controlling the amount of conditioner added and for continuous record of H-ion concentration have been developed.

9. Fort Worth Proposed Sewage Improvement. O. E. Carr. Consulting engineer recommends partial aeration with sprinkling filters in connection with existing Imhoff tanks.

10. The Jacksonville, Texas, Sewage Disposal Plant. H. L. Thackwell. The unique features of this plant are a brushwood colloider, separate sludge digestion, high head dosing tank, glass covered drying beds, chlorination and final step-aerator.

11. Waco's New Activated Sludge Plant. C. C. Hays. Waco's new activated sludge plant was designed for 4 m. g. d. It consists of a three-division grit chamber, pre-sedimentation tanks with Link Belt sludge removers, Manchester type aeration tanks and Dorr clarifiers.

12. Sewage Treatment in the Region of Chicago. Paul Hanson. The region around Chicago is rapidly becoming the center of sewage treatment development of the world. Numerous sanitary and conservancy districts have been organized to plan, build and maintain adequate treatment works for the disposal of sewage. Every sewage treatment device known and many still in their experimental stage can be found under exceptionally good technical control in this region.

13. Sewage Works Analyses. F. W. Mohlman. Sewage analyses should be standardized with elimination of some of the less essential determinations, such as oxygen consumed and albuminoid ammonia. The more informative determinations should be adopted, such as biochemical oxygen demand, organic plus ammonia nitrogen and suspended solids. Standard equipment, dilution water, and methods for the B.O.D. determination have been adopted for use in the eleven laboratories of the Sanitary District.

14. Industrial Waste Work of the Sanitary District of Chicago. F. W. Mohlman. Studies of the industrial wastes in Chicago showed that activated sludge treatment was most effective for packing-house waste, screening and sedimentation, possibly with coagulation by alum, at the individual

tanneries for tannery waste, and trickling filters for corn products wastes. Recovery of wastes in the Argo plant of the Corn Products Refining Company has eliminated the necessity of treating its wastes. The study of waste from a chemical plant manufacturing Paris green, dyes and intermediates showed that acid wastes can be treated by partial neutralization with limestone; arsenic and copper by precipitation with lime; and sulphite liquors can be used for further neutralization of acid wastes.

15. Stream Pollution—Self Purification of Streams. H. W. Streeter. The stabilization of organic matter and bacterial purification in a stream are functions of time and vary with changes in temperature. Plankton apparently plays an important role in stream purification.

16. The Oil Field Salt Water Pollution Problem. J. S. McIntosh. The oil industry has tried various methods of impounding the salt water, which is the greatest source of pollution from the oil fields, and draining it off through streams during the season of high flow. The industry has even gone to the extent of acquiring riparian rights on streams not used for domestic water supply in order to secure proper drainage. No satisfactory method of treatment for the salt water has yet been found.

17. Separate Sludge Digestion at Antigo, Wisconsin. Anthony J. Fisher. The average of results for fifty-one weeks operation of the separate sludge digestion tank at Antigo are: temperature of sludge 70.3° F.; cu. ft. of gas per pound volatile solids, 11.5; per cent solids in digested sludge, 8.9; per cent ash, 57.5; gas produced, 0.8 cu. ft. per capita per day.

18. Irrigation with Sewage Effluents. W. A. Riney. Abilene, Texas, disposes of effluent from septic tanks by contracting with farmers to use the effluent for irrigation of row crops.

19. Calculating the Capacity of Sludge Digestion Tanks. Karl Imhoff. Population, temperature, seeding and other factors must be considered in determining the capacity of sludge digestion tanks. Studies in Germany where the mean sewage temperature is 50° F. yield the following values of requisite capacity for various tanks: two story tanks, 1.0 cu. ft. per capita; deep separate digestion tanks, 1.7 cu. ft.; two-story tanks with heated digestion tanks, 0.7 cu. ft.; separate digestion in shallow earthen basins, 3 to 7 cu. ft. The values vary with changes in temperature.

20. Some Data on Partial Aeration of Strong Sewage with Activated Sludge. William D. Hatfield. Partial aeration of a strong sewage with activated sludge removes a considerable amount of the biochemical oxygen demand and tends to break down the soluble and colloidal organic matter so that it may be applied to sprinkling filters at a much greater rate than can settled Imhoff effluent. This method of treatment is particularly promising for increasing the capacity of overloaded filter plants.

21. Activated Sludge Progress and Problems. A. J. Martin. Recent progress in the activated sludge process tends toward the development of

mechanical aeration with a view to reducing power costs. Dewatering and disposal of the sludge is by far the hardest problem met with in the development of the process.

22. The Treatment of Industrial Wastes. Edgar Whedbee. Activated sludge has been used successfully in the treatment of packing house and creamery wastes, sedimentation after treatment with lime seems best for straw-board waste, and wastes high in carbohydrates can be treated by activated sludge process when preceded by fine screening.

Visit of German Engineers

A group of nine German sanitary engineers and chemists visited the United States in May, June and July of this year. Practically all of the members of the group are closely associated with sewage treatment in Germany and consequently their visit included the major sewage treatment works in this country.

The party was headed by Dr. Max Beninde, President of the German Hygienic Institute (Die Preussische Landesanstalt für Wasser-, Boden- und Lufthygiene, Berlin-Dahlem). The other members of the party were:

Dr. B. Bürger, Director of the Division of Bacteriology, Hygienic Institute, Berlin-Dahlem.

Friedrich Langbein, Director of Sewage Disposal of the City of Berlin.

Dr. Heinrich Helbing, Director of Public Works of the Emscher District, Essen.

Dr. Max Prüss, Director of Sewage Works of the Emscher District, Essen.

Karl Fehring, Director of Public Works of the Lower Rhine District, Moers.

O. Mohr, of the German Sewage Treatment Corporation (O M S Process), Wiesbaden.

Fr. Mieder, Director of Public Works, Leipsic.

Dr. W. Hilland, Chemist of the International Dye Industry, Bitterfeld.

The party visited New York, several sewage treatment plants in New Jersey, Baltimore, Washington, Pittsburgh, Indianapolis, Chicago, St. Louis, Denver, Salt Lake City, Yellowstone National Park, Antigo, Wis., Milwaukee, Detroit, Cleveland and Buffalo. They landed in New York May 27 and sailed for Europe July 6, 1928.

The work of the sanitary engineers in this group is not so well known as that of Drs. Imhoff and Sierp of the Ruhrverband, both of whom have visited the United States in former years.

Dr. Beninde is President of the German institute which is somewhat

similar to our Hygienic Laboratory at Washington. Research and practical investigations are carried on in all branches of sanitary science, the results of which are published in various bulletins, monographs and reports. One of the most recent of the "Kleine Mitteilungen" is a bulletin of 518 pages which contains complete papers presented at a sanitary congress held in Essen in June, 1927. These papers summarize the present status of sewage research and sewage treatment in Germany. They will be abstracted in later issues of THIS JOURNAL.

Dr. Bürger is head of the division of bacteriology of the institute. He has worked mainly on the bacteriology of water and sewage, and the identification of *Bact. coli*.

Langbein is in charge of sewage pumping stations and treatment works of the city of Berlin. He is now interested in the installation of a fairly large activated sludge plant for several hundred thousand people in a suburb of Berlin, where he has operated a testing station for some time. The sludge digestion tanks are to be of the type developed by Dr. Max Prüss, as noted below. Langbein thinks he will get enough gas from sludge digestion to supply power for compression of air for the activated sludge tanks.

Dr. Helbing is in charge of the work of the Emscher District, in the position formerly held by Dr. Imhoff. The Emscher District has a population of 2,300,000 and includes nine cities with populations of 100,000 or more. Essen and Dortmund each have more than 300,000 population. The sewage of 1,400,000 people in this district is treated in Imhoff tanks. Industrial wastes are mainly from steel plants, coal-washing plants, and the by-products coke industry.

Dr. Max Prüss is in charge of the design, construction and operation of sewage and industrial waste treatment plants in the Emscher District. He has installed a number of separate sludge digestion plants, in which the sludge is circulated from bottom to top of tanks 30 feet deep. The sludge is pumped by an enclosed turbine which completely overturns the tank contents in two hours pumping per day. Dr. Prüss believes that the circulation accelerates gas production by liberation of gas as the pressure is reduced, also that toxic end-products of bacterial action are dissolved as the sludge particles fall through the upper layer of sludge liquor. He claims that gas production is nearly doubled by this daily circulation and that the time of digestion is halved, as compared with quiescent sludge. Tanks of this description have been installed at Essen-Frohnhausen, Essen-Nord, Oberhausen, and Gelsenkirchen-Nord, all cities of from 25,000 to 50,000 population.

Karl Fehring is in charge of sanitary engineering construction in the Lower Rhine district, which has a population of 260,000 and lies between the Rhine on the east and the Dutch frontier on the west. This district

is highly industrialized along the Rhine near Moers, Duisberg and Wesel, where the German Solvay Works are located, also steel works and mines. The disposal of the wastes from industries is one of the major problems of this district.

O. Mohr is director of the German Sewage Treatment Corporation at Wiesbaden, which manufactures and installs the O M S process. The O M S tank is somewhat similar to the Imhoff tank, but the entire flowing-through chamber is submerged, so that scum and floating material are trapped and introduced into the digestion chamber Other types of settling tanks and sewage treatment devices are built by this company, particularly for the treatment of industrial wastes.

Dr. Mieder is enlarging the Leipsic sewage treatment plant. Chlorination of settled sewage has been practised for several years at Leipsic, in order to improve conditions in the Luppe and Elster Rivers. Mieder is interested in the development of a new type of mechanical scraper for removing sludge from settling tanks.

W. Hilland is interested in the use of chlorine and chemicals in sewage treatment.

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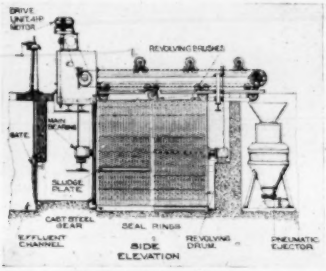
Sewage Treatment Plant Equipment



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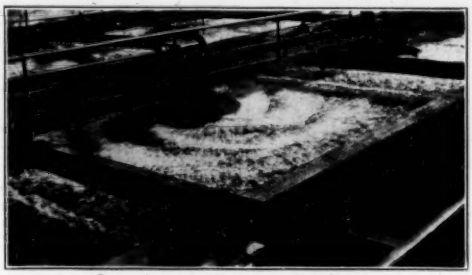

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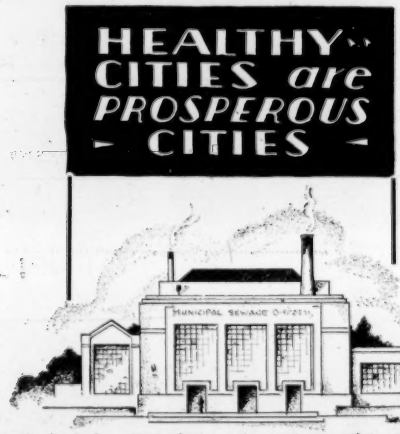

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INDEX TO ADVERTISERS

	Page
Cast Iron Pipe Research Assn., Chicago, Ill.	5
The Dorr Company, New York City	4
Electro Bleaching Gas Company, New York City	12
Jerry Donohue Engineering Company, Sheboygan, Wis.	10
W. G. Kirchoffer, Madison, Wis.	10
LaMotte Chemical Products Co., Baltimore, Md.	6
Link-Belt Company, Philadelphia, Pa.	7
Lord & Burnham Company, Irvington, New York	8
The Mathieson Alkali Works, Inc., New York City	3
Pacific Flush-Tank Company, New York City	11
Pearse, Greeley and Hansen	10
Sewage Works Journal	9
Simplex Ejector and Aerator Corp., Chicago, Ill.	9
Wallace & Tiernan Company, Inc., Newark, N. J.	Back cover

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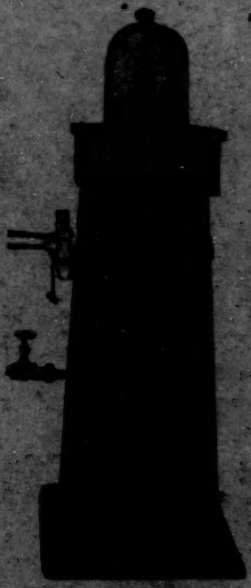

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